THE SOCIETY OF

PLASTICS ENGINEERS JOURNAL

STEVENS RICE
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14 A

Studying Plastics with Infrared

see page 537

JULY, 1959 • VOLUME 15, NUMBER 7

G.Q.* m.s.!

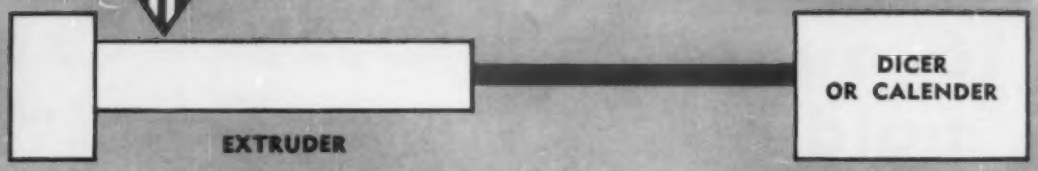
*GERING QUALITY MEANS SAVINGS

GERING

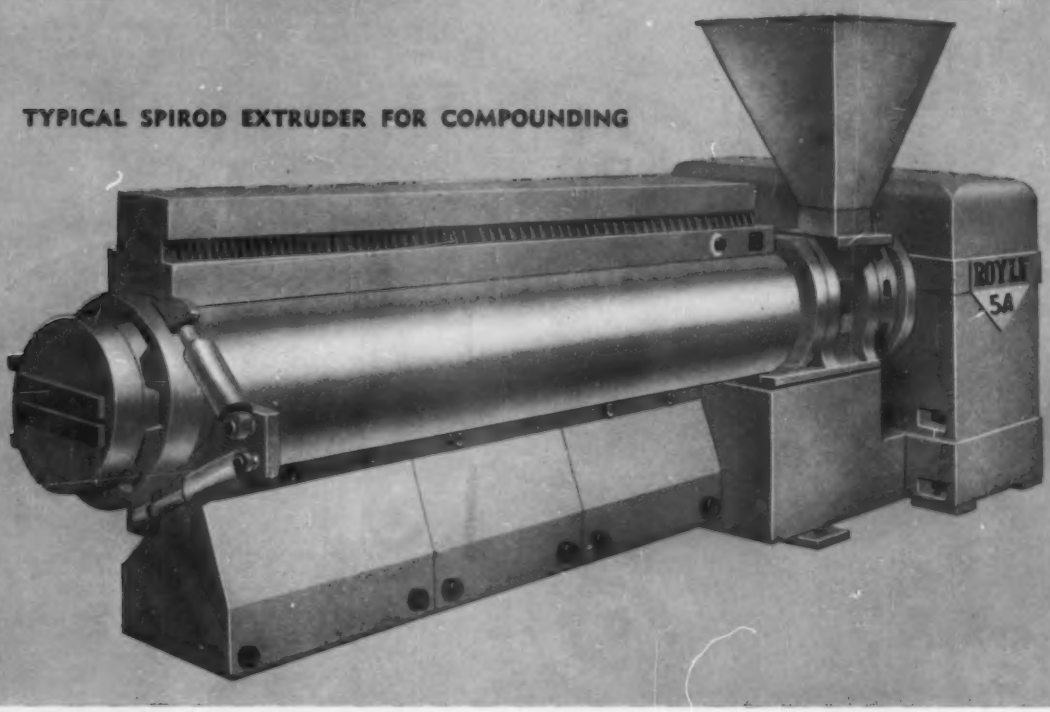
Molding Compounds

ROYLE SPIROD Extruders

FOR PREPLASTICIZING AND RECLAIMING



TYPICAL SPIROD EXTRUDER FOR COMPOUNDING



Many compounders are now taking advantage of rugged **ROYLE SPIROD** extruders in their operations. Check these features:

- **Thrust bearings, with positive internal lubrication, designed for 10 years' minimum life.**
- **New dual head arrangement for reclaiming or coloring work; allows continuous operation while fixtures and screens are cleaned.**
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16-ounce molding machine

Available in 3 new models,
the Farrel Watson-Stillman 16-ounce injection molding machine permits the choice of an injection rate that is ideally suited to the type of plastic to be molded. The three designs differ in injection-ram speeds, but are similar in other respects.

Hydraulically operated, the machine has manual and automatic single-cycle controls.

New bulletin 622-A gives complete details and specifications of this machine. Write for a copy today.

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Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
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Represented in Canada by Barnett J. Danson, 1912 Avenue Road, Toronto, Ontario
Manufactured in Canada by Canadian Vickers, Limited
Represented in Japan by The Gosho Company, Ltd., Machinery Department, Tokyo, Osaka, and Nagoya

WS-62

SPECIFICATIONS

	16ES-400	16ES-400M	16ES-400S
Maximum amount of material per shot—			
Styrene	16	16	16
Injection rate (cubic inches per min.)	1,080	1,310	1,620
Daylight opening	34"	34"	34"
Maximum die sizes	20" x 36" and 21" x 33"		

Which injection rate is right for you?

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COMING SOON . . . SOMETHING NEW IN PREPLASTICIZING

Photo courtesy of R. E. Dietz Company

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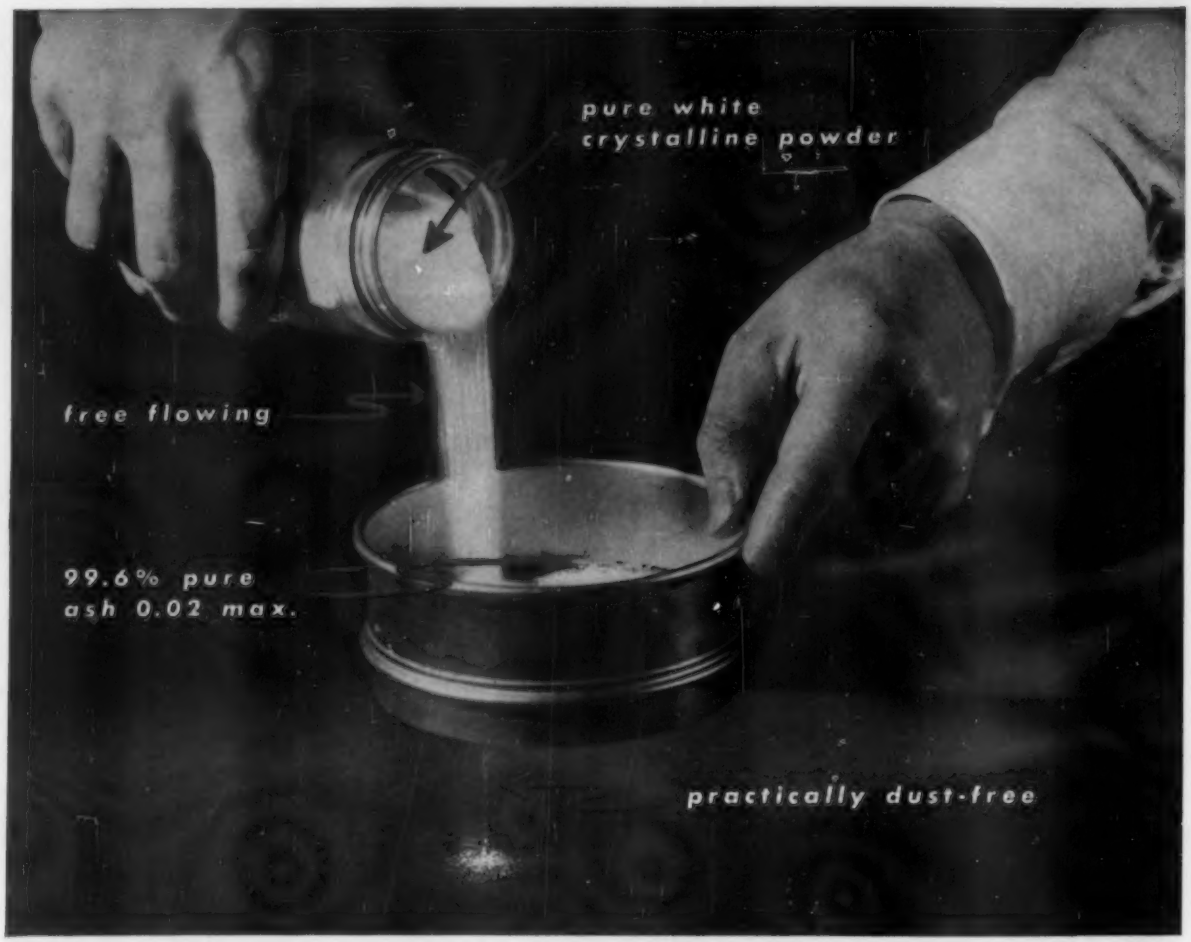

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Although rigid and form retentive, Fortiflex contributes sound deadening properties that virtually eliminate the need for acoustical padding.

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TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	−200	−180	−160	−100
Impact Strength, Izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hr. immersion @ room temp.)	D-570-54T	% wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
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Please send: ☐ more information on, ☐ test quantities of Fortiflex.

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Charles E. Rhine
Editor

EDITOR'S NOTEBOOK

KEEP PLASTIC FILM AWAY FROM CHILDREN

When a garment is ready to be worn, tear off the film covering and discard it, unless it is to be reused for a similar purpose. Just as children are not permitted to play with pills and medicines, keep thin plastic film away from them.

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PLASTIC FILM

CORRECT USE AND MIS-USE

HELPFUL HINTS TO PARENTS

AN IMPORTANT MESSAGE TO PARENTS ABOUT PLASTIC BAGS

THE PROBLEM:

In recent months a number of infants and small children have died as a result of the misuse of ultra-thin plastic bags, such as those used to protect your clothing after cleaning and laundering. For example, these bags were used as loose, makeshift covers for crib mattresses. The ultra-thin film adhered to the mouth and nose of the infants, causing suffocation. This is a tragic — and unnecessary — price to pay for the convenience of these new bags.

A FATAL MISTAKE . . .
This is the worst possible use a mother could make of an ultra-thin plastic bag. Though it might protect the mattress from wetting, it could well lead to a fatal accident.

INVITATION TO DANGER . . . The wrong thing to do with a plastic film bag . . . While the plastic bag will protect the pillow from perspiration, it exposes the child to the danger of suffocation.

WHAT YOU CAN DO ABOUT IT:

You can use caution and common sense. **Never** use a plastic bag as a makeshift cover in cribs, play pens, baby carriages, for mattresses or upholstery. **Never** give a plastic bag to a child as a plaything. It is not for children. It should be kept out of their reach. **Never** keep a plastic bag after it has served its intended usefulness.

Destroy it: Tear it up . . . or tie it in a knot . . . and throw it away.

WHEN THEY HAVE SERVED THEIR PURPOSE

TEAR THEM UP . . .

OR TIE THEM IN A KNOT LIKE THIS . . .

AND THROW THEM AWAY.

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Charles E. Rhine

Editor

EDITOR'S NOTEBOOK

PLASTICS FILM

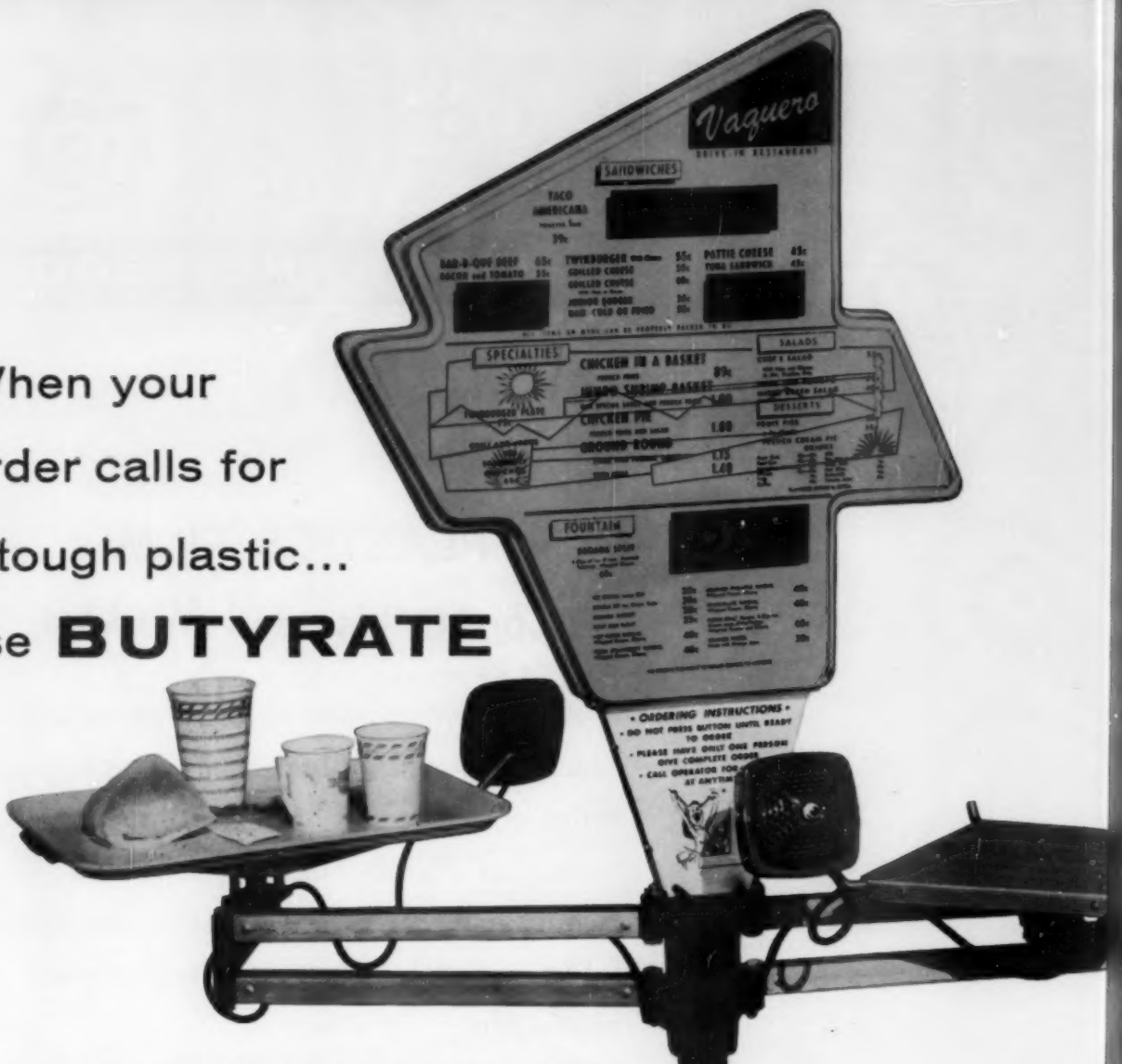
Correct Use and Mis-Use

As its contribution to the comprehensive educational and public relations campaign being conducted by our sister Society, The Society of Plastics Industry, Inc., SPE is attaching herewith a copy of SPI's educational folder on the correct use and mis-use of plastic film.

Since the success of this campaign hinges directly or indirectly on the interests of every SPE member, their assistance in spreading this information to users of plastic film will be appreciated by our National Officers.

Additional copies of this folder may be obtained on request to The Society of Plastics Industry, Inc., 250 Park Avenue, New York 17, N.Y.

When your order calls for a tough plastic... use **BUTYRATE**



Hungry motorists can see what's good at a glance with this internally lighted, double-faced menu sign. It is part of a new electronic ordering system that speeds service at drive-in restaurants. Each unit includes the sign and two microphone speakers, all vacuum-formed from sheet extruded of Tenite Butyrate plastic.

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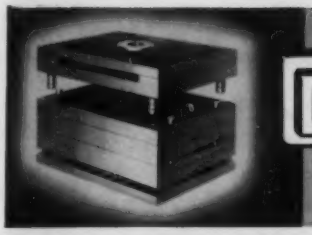

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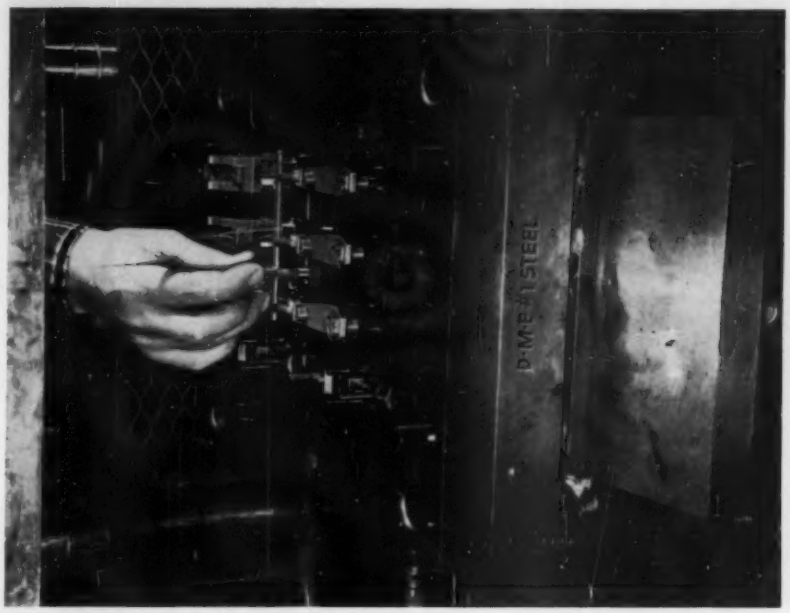

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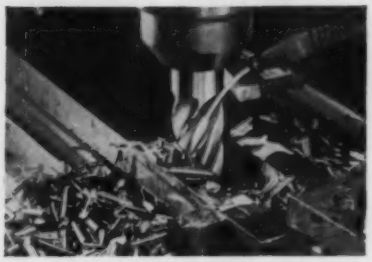

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59-A

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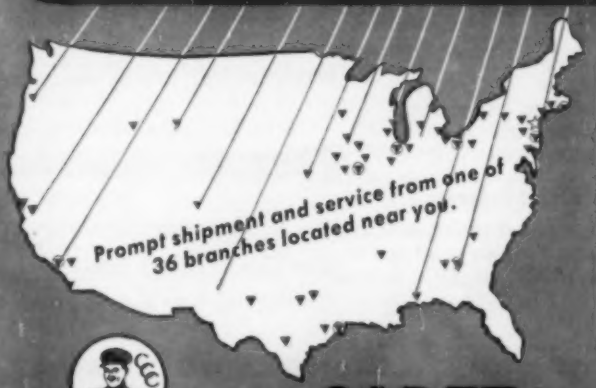

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PLASTICS ENGINEERS JOURNAL

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INFRARED SPECTOPHOTOMETRIC STUDIES OF PLASTICS

Raymond Sawyer

The Perkin-Elmer Corp.
Instrument Div.

THE EMPLOYMENT of infrared spectroscopy to the study of polymeric substances of high molecular weight has received a vast amount of emphasis during the past decade. Through infrared spectrophotometric techniques structural parameters such as branching, amorphous character, unsaturation and crystallinity have been studied and much information has been obtained concerning the molecular structure of plastics.

Instrumentation and Experimental Techniques

At present there are available several infrared spectrophotometers which lend themselves adequately to the problem of obtaining infrared spectra of plastics. The spectrophotometers differ in cost, versatility, resolution, scanning speeds, chart size and hence, chart readability. The particular choice of an infrared spectrophotometer will be governed by the nature of the extent to which the individual desires to pursue the infrared study of plastics. The more information one desires relating to the molecular structure of the particular plastic molecule being investigated, the more costly will be his instrumentation investment.

NOTE: Graph printed in color across this page represents the infrared spectrum of a sample of polystyrene film.

There are several experimental procedures which may be used for the preparation of plastic samples for infrared investigations.

(1) The sample may be dissolved in an appropriate solvent, and the resulting viscous solution spread uniformly over an alkali halide plate. The solvent may then be removed by heating under vacuum or by normal evaporation at room temperature.
(2) Films of the plastic material may be suitably mounted in a holder for introduction into the infrared spectrometer.
(3) The plastic, while in a viscous state, may be painted on a metallic surface and then investigated using infrared reflectance methods.
(4) Plastics are produced in different molecular weight grades varying from soft greases to hard plastics and hence the lower molecular weight species may be studied simply by pressing a small amount of the material between two alkali halide plates.

There are many different types of resins and plastic materials classified according to their origin such as acrylic resins, alkyd cellulosics, epoxy, ethylene, phenolics, styrene polymers, etc. These may differ in length in $-CH_2$ chain, carbonyl content, aromatic ring structure, hydroxyl content, etc. Infrared spec-

troscopy has played an important role in unraveling these structural differences. This paper will devote itself to presenting some of the applications of infrared spectroscopy to the different types of resins and plastics.

Phenolic Resins

The vibrational spectra of many substituted phenols and related compounds and of many resins formed from phenols and aldehydes have been studied for the possibility of formulating correlation rules for use in determining structural features of this class of resins. From the absorption bands observed in the 700-900 cm^{-1} region it may be possible to infer the type of substitution around the aromatic nuclei in these complex molecules. The absorption of hydroxyl groups in the 3,200-3,500 cm^{-1} region indicates to the investigator or analyst the differences in the types of hydrogen bonds in the different compounds. The infrared spectrum of resins formed by the condensation of phenols with aldehydes provides insight into the mechanism of condensation and the nature of cross linkage in these structures. Clear differences exist between the infrared spectra of the phenol-formaldehyde resins at different stages of condensation. The two-stage fusible resin differs from the one-stage resin in having a stronger band at 1,105 cm^{-1} and weaker absorption between 950 and 1,050 cm^{-1}. The two-stage infusible resin shows the band at 880 cm^{-1} more strongly, and has intense absorption between 900 and 1,000 cm^{-1}. All other resins show significant differences in the 900-1,500 cm^{-1} region. For example, novolacs of different melting points differ in the region 1,100-1,300 cm^{-1} and the resol has a strong band near 1,070 cm^{-1} which is associated with the $-CH_2OH$ group. The differences in their infrared spectra reflect the different nature of the phenolic material used in their preparation. It is difficult to assign the absorption bands observed in the 1,000-1,500 cm^{-1} region to particular normal modes, although in this region vibration bands occur which are associated with C-O-C, C-O-H, CH_3, and CH_2 groups as well as of the skeleton of aromatic nuclei. It is evident that in these cases the exact position of a particular band depends upon the environment of the group within the molecule.

Ethylenic Resins

The polymerization of ethylene at elevated temperatures and increased pressures results in polyethylenic resins of high molecular weight hydrocarbons. Infrared spectrophometric investigations suggest that these polyethylene molecules are branched and indications of the presence of unsaturation in these molecules has been observed (Fox, Proc. Roy. Soc. London A175, 1940 and Thompson, *Ibid*, A184, 1945). Further infrared studies revealed that the crystalline content of polyethylene decreases as the degree of branching increases. By employing polarized radiation some indication of the nature of the orientation of the segments in the crystalline form of polyethylene may be obtained. By means of cold drawing and heat relaxation techniques followed by observing changes in the infrared polarized spectra, one is able to obtain information concerning how many different crystalline forms are present and also which particular crystalline form is favored under a particular set of experimental conditions.

The employment of infrared quantitative techniques enables one to determine the $-CH_3$ content of polyethylene resins, $-CH_2$ —content, $-C=C$ —content, and the average number of branches per 100 carbon atoms. These measurements should be conducted in the liquid state in order to eliminate interferences from amorphous and crystalline state. The infrared spectral studies clearly indicate that unsaturation concentration decreases with increasing molecular weight and hence the infrared spectrophometric technique may be used to measure total unsaturation when one employs reference compounds and conducts measurements in the liquid state to eliminate crystallinity effects.

Figure 1. Celanese Corporation has cut some testing costs in half through use of a low-cost infrared spectrophotometer. Celanese uses the instrument for precise quality control of ingredients going into the production of plastic materials.

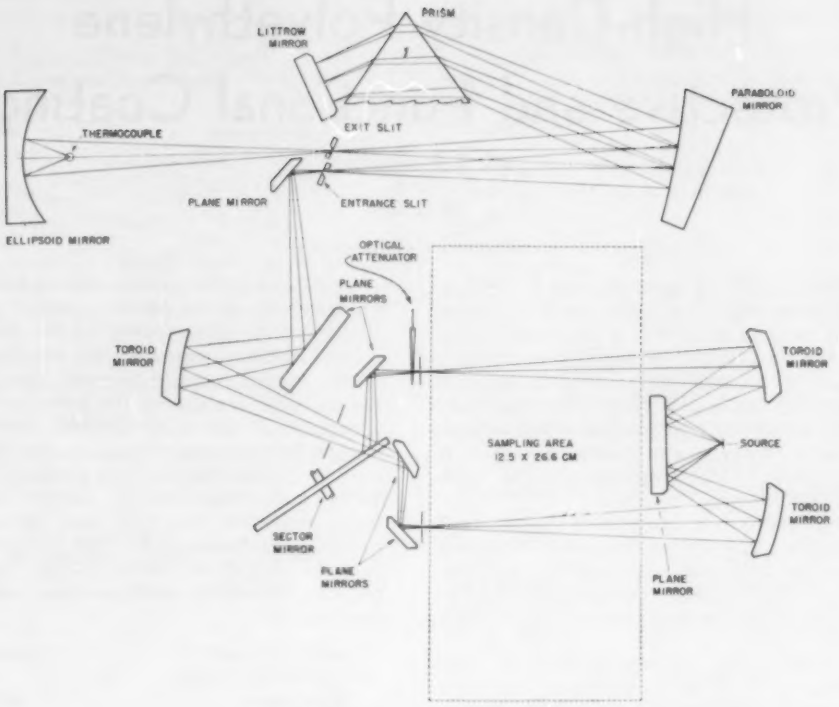


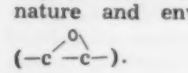
Figure 2. Schematic of optical system.

Cellulosics

The cellulose molecule presents a very complex system being composed of 2,000 to 3,000 glycosidic units. The final product is dependent upon many experimental factors. The infrared spectra of these polymers provide information concerning hydroxyl content, nature of hydrogen bonding, character of nitrate groups in the case of cellulose nitrate, differences between cellulose esters and ethers. Absorption bands characteristic of the cellulose ring and the effect of substituents on the cellulose ring are readily observed from the infrared spectrum.

Epoxy Resins

Condensation polymers produced from epichlorohydrin and bisphenol form a resin referred to as an epoxy resin. Infrared spectroscopy has contributed much in the development of techniques for the determination of changes in molecular weight of epoxy resins by correlating changes in the infrared absorption band intensity as a function of the epoxide equivalent. From infrared spectrophotometric techniques much information is gained concerning the nature and environment of the epoxide group



Vinyl Type Resins

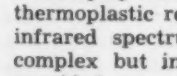
The polymerization of vinyl chloride results in a thermoplastic resin which is polyvinyl chloride. The infrared spectrum of this type resin is extremely complex but interpretation of spectral studies has provided some data on chain length, methylene groups, and the nature of the C-Cl linkages. Information concerning the absence or presence of plasticizing agents in polyvinyl chloride resins may be obtained from the infrared spectra.

Interpolymers are formed by the copolymerization of vinyl chloride and vinyl acetate. These resins have infrared spectra which are quite complex and somewhat similar to each other. The differences observed in absorption band intensities may be related to the magnitude of polyvinyl acetate in the copolymer.

Many copolymers using vinyl chloride have been produced and studied by means of infrared spectrophotometric methods. The resulting infrared spectra have not been comprehensively interpreted due to their complexity. However, the spectra have provided much data relating to nitrite groups, carbonyl groups and unsaturation linkages.

Acrylic, Alkyd, and Amino Type Resins

These three classes of resins have been subjected to very extensive study by infrared techniques and many structural correlations associated with these molecules have been postulated. Group frequencies observed in the spectra of acrylic resins agree with the postulated structure of this molecule. The alkyd resin spectra is more difficult to interpret and correlation of the observed infrared absorption bands with structure and mode of preparation has been tedious. Spectral changes due to copolymerization have been studied by observing band intensity changes under different experimental conditions. Amino resins are extremely complex and the infrared spectral studies have provided much data concerning the nature of C=O groups, =N–H groups, and



groups in these complex resins. Resonance effects on the C=O linkage and absorption band shifts associated with the ionized carboxyl groups have been studied by means of the infrared spectra.

High-Density Polyethylene Protective and Functional Coatings

S. E. Hmiel
and
H. G. Guy

Koppers Company, Inc.

SINCE THE DISCOVERY of polyethylene in 1933, a number of processes have been developed to obtain polyethylenes of various densities. It has been found that as the density increases, the rigidity as well as solvent, chemical and permeablity resistances are also increased. A recently developed variation is the "low pressure" polyethylene. This polyethylene has a relatively high density (0.95) and is classified as ASTM Type III. Lower density polyethylene, (ASTM Type I) has a 0.910-0.925 density.

The Type III polyethylene, because of its chemical inertness and physical properties, has been suggested for use as protective and functional coatings for metallic substrates. Until recently, the lack of suitable application processes has limited the use of this particular material.

A practical method for the application of high density polyethylene to metallic substrates has been developed and tested both in the laboratory and in the field. This method may be outlined as follows: The type III polyethylene, as a finely divided powder, is dispersed in polar or non-polar liquid media to form semi-stable dispersions, Table I. The dispersions are applied at room temperature to hot or cold targets with conventional spray equipment. The sprayed object is then baked in an oven to fuse the polyethylene to itself and the substrate. The bake cycle is followed by either a water quench or is gradually cooled to room temperature. The high density polyethylene dispersion coatings so obtained are adherent, flexible and continuous with outstanding resistance to impact, separation and chemical attack.

Application processes in the past had been developed for use with lower density polyethylene (ASTM Type I). These processes include:

1. *Sintering* - The fusion of powdered polyethylene to the substrate with heat.[1]
2. *Flame Spraying* - The powdered polyethylene is sprayed through a flame directly to the substrate.
3. *Fluid Bed* - The powdered polyethylene is suspended as a bed by a gas. A preheated metal part is dipped into the fluid bed and the polyethylene fuses to the part. A post heating period is generally required for final fusion and flow.
4. *Solution* - The polyethylene (5-10% by weight) is dissolved in hot solvents and applied while still hot to the substrates.
5. *Emulsions and Suspensions* - Polyethylene emulsions and suspensions are available, but are not generally used for metal coating.[1a]
6. *Dispersions* - Low density polyethylene dispersions have been available but have not been generally accepted.[2-5]

[1] U. S. Patent 2,737,461
[1a] U. S. Patent 2,868,742
[2] U. S. Patents 2,313,144 and 2,384,848
[5] French Patents 1,050,223; 1,042,310; 1,055,561; 1,059,221 and 1,063,919

The above application processes have found limited success because the permeability of the polyethylene was found to be increased by the degradation of the polymer that occurred during the fusion process.

The higher density polyethylenes have not been successfully applied by the above processes with the exception of the fluid bed technique. However, the size of the fluid bed limits in size the objects which may be coated and tends to produce uneven coatings. Tests with high-density polyethylene dispersions have indicated that they may be used for coating metallic substrates of various sizes and shapes. These coatings might be useful in the steel, automotive, marine, electrical, refrigeration and packaging industries for:

1. Steel Containers	—Corrosion Resistance
2. Chemical Process Equipment	—Corrosion Resistance
3. Electrical Insulators	—Electrical and Corrosion Resistance
4. Ice Cube Trays	—Non-wetting and Quick Release
5. Motorboat Propellers	—Corrosion and Abrasion Resistance
6. Tubular Products	—Corrosion Resistance
7. Other Intricate and Irregular Shapes	

Description of Dispersions and Process

The typical physical properties of Type III polyethylene dispersions were given in Table I. These dispersions differ in the type of liquid medium used to disperse the higher-density polyethylene. The polar type is based on water and water-miscible organic solvents. The non-polar type is a water-immiscible system. The advantages of either system depend upon the end use application. In flammable areas, the polar type may be used to lessen the danger of explosion. The polar-type dispersion may require a rust inhibitor and has shown a slower evaporation rate than the non-polar type.

The approximate coverage per gallon for both dispersions described in Table I was calculated to be 500 mil square feet. The losses caused by overspray could be eliminated by using a collecting system. The losses incurred thereby would be kept at a minimum and the calculated coverage value should be closely approached.

High density polyethylene dispersion coatings, 2-30 mils thick were applied in a single coating application with a spray gun. The coating thickness was controlled by the position of the gun, the type and amount of atomization at the fluid nozzle and/or the number of gun passes. When applying thick coatings, the spray gun was adjusted to give complete atomization to reduce the quantity of solvent deposited on the substrate with the polyethylene. This reduced or eliminated solvent bubbles.

TABLE I

Typical Property Values for Type III Polyethylene Dispersions

Property	Typical Values: Non-Polar Type, Solvent	Typical Values: Polar Type, Water
Solids Content, wt. %	40-45	35-40
Weight per Gallon	7.2	8.0
Approximate Coverage per Gallon	500 mil sq. ft.	500 mil sq. ft
Single Application Thickness	2-20 mils	2-20 mils
Viscosity	Medium-Heavy	Medium-Heavy
Storage Stability	Polymer may be readily re-dispersed after 3-6 months providing evaporated liquid is replaced	

TABLE II

Suggested Bake Cycles for High Density Polyethylene Dispersion Coatings

Temperature °F	20 Gauge Cold Rolled Steel Sheet (Time in Minutes)	¼" Wall Steel Pipe (Time in Minutes)
350	30	45-60
400	15	20-30
425	12	20-30
450	10	15-20

Multiple coats of polyethylene were also applied with a short bake cycle following each application. It was found that the second coat could be applied either to cooled or hot coatings (i.e. 400°F). Uniform coatings were obtained using both techniques.

The medium-heavy viscosity of the dispersions was adjusted for spraying, dipping or flow coatings by the addition of the appropriate thinner. The thinner was the same liquid medium as used in the preparation of the dispersion.

High-density polyethylene dispersion coatings were applied to cold and hot rolled steels, stainless steel, aluminum and copper. Solvent degreasing, grit or sand blasting or acid pickling methods were employed to prepare the substrates for coating.

The bake cycles investigated are shown in Table II.

For sheet metal, the 400°F-15 minutes bake gave the best results. The 450°F-15 minutes bake cycle was found the best for ¼"-wall steel pipe. The higher bake temperatures were found to be more satisfactory for thick walled objects. A rapid heat-up of the substrate usually resulted in smoother coatings. It was also found that a pre-heat of the object followed by the dispersion application and bake resulted in smooth coatings. Polymer degradation occurred when long bake periods were used. To control polymer degradation, an antioxidant was added to the dispersion.

The post-treatment of the coating after the bake had an effect on the physical properies of the high density polyethylene coatings. Quenching the hot coating with cold, tepid or hot water resulted in transparent and glossy coatings which exhibited excellent flexibility and impact resistance. However, the water quenching did cause the polyethylene to shrink away from sharp corners and edges.

TABLE III

Antioxidant Effect on Color of Coating Average 8-mil Thickness

Time-Minutes at 400°F	Color of Coating Unstabilized Dispersions	Color of Coating Stabilized Dispersions
5	Natural	Natural
10	Natural	Natural
15	Natural	Natural
20	Slight Tan	Natural
25	Tan	Natural
30	Brown-Dull	Natural
45	Black Brown	Slight Brown
60	Black	Brown

TABLE IV

Pigments for High Density Polyethylene Dispersions

Pigment	Supplier
Titanium Dioxide RA-50	Titanium Pigment Corporation
Chromium Oxide X-1134	Imperial Paper and Color Corp.
Cadmium Red	Harshaw Chemical Corp.
Cadmium Yellow	Harshaw Chemical Corp.
Ultra Marine Blue	American Cyanamid Corp.
Pigment Green "B"	E. I. DuPont de Nemours

TABLE V

Physical Properties of High Density Polyethylene Coatings Applied on Cold Rolled Steel Sheet From Either Water or Solvent Type Dispersions

Property	Test Method	Finding
Appearance	Visual Inspection	Smooth, glossy and transparent to translucent
Continuity	30,000 volt electrode, 8 ±2 mils coating thickness	No pinholes
Flexibility	Conical Mandrel, ⅛" bend	No rupture
Peel Resistance	American Water Works Assn. Test	No peel
Impact Resistance	Gardner or Falling Ball Tester, 56 inch-pounds impact on coated or uncoated face	No rupture
Heat Resistance	American Water Works Assn. Test, 72 hours at 160°F dry heat	No loss of impact or peel resistance
	American Water Works Assn. Test, 5 hours at 160°F in water	No change of adhesion

Cooling the coatings gradually in air resulted in translucent and dull coatings. The coatings ruptured on ⅛" mandrel bends and 56 inch-pounds reverse impact.

Oven annealing gradually cooled the coating from bake to room temperature and resulted in coatings having excellent flexibility and impact resistance. The gloss was not as pronounced as that obtained by water quenching. The shrinkage problem was also minimized.

Studies have been made to determine the mechanism of bonding polyethylene to metals. It has been reported that the bonding of polyethylene to metals is markedly increased by the oxidation of the polymer under the proper conditions. The bond strength of the oxidized material is ascribed to dipole-ion interactions. Studies through infrared analyses reveal the formation of carbonyl groups during the baking process. This offers an explanation of the bonding action.

Uniformly tinted coatings were obtained by pigmentation of the dispersisons with heat stable pigments. These colored dispersions were prepared by the addition of pigment to the dispersion with agitation. The pigments used satisfactorily are listed in Table IV. Zinc oxide promoted embrittlement of the polyethylene coating and was not satisfactory.

Physical, Chemical and Functional Properties

Table V summarizes the properties of the higher density polyethylene coatings on cold rolled steel sheet. The panels had been spray coated, baked at 400°F-15 minutes and water cooled. An average thickness after baking of 8 ± 2 mils was required to obtain pinhole free coatings. The continuity was measured with a K-D Bird Dog flaw detector or a 30,000-volt spark tester. The thickness was measured with an Elcometer. These coatings did not rupture on a ⅛" radius bend with a conical mandrel. The reverse impact with a 56 inch-pound load did not rupture the coating.

These coated panels were immersed in water at 160°F for five hours without a noticeable change in adhesion. However, prolonged exposure at this temperature caused embrittlement of the coatings and should be avoided.

High-density polyethylene coated cold-rolled steel was exposed to liquid, vapor and liquid-vapor phases of various chemicals, solvents and commercial preparations. The coated panels had an average thickness of 10 mils and were pinhole free. No corrosion of the substrate was observed for the various test media except glacial acetic and hydrochloric acid. These acids permeated the polyethylene coatings and attacked the metal substrate. These corrosion tests with other media are still in progress and the coatings have not failed after three months' exposure.

The test media were as follows:

1. *Acids*
   - A. Acetic acid, glacial and aqueous solutions
   - B. Battery acid and concentrated sulfuric
   - C. Hydrochloric, concentrated and dilute aqueous solutions
   - D. Ortho Phosphoric
   - E. Nitric, concentrated
2. *Bases*
   - A. Ammonium hydroxide, concentrated and aqueous solutions
   - B. Caustic soda, saturated and aqueous solutions
   - C. Monoethanolamine
3. *Peroxides*
   - A. Hydrogen peroxide—3% aqueous solutions
4. *Salts*
   - A. Sodium chloride, saturated and dilute aqueous solutions
   - B. Copper sulfate, dilute aqueous solutions
5. *Detergents*
   - A. Orvus 5% aqueous solutions
   - B. Dreft 5% aqueous solutions
   - C. Triton X-100, concentrated and 5% aqueous solution
6. *Solvents*
   - A. Xylene
   - B. Sour crude oil
   - C. Mineral oil
   - D. Ethylene glycol
   - E. Methyl ethyl ketone
   - F. Methanol
7. *Water*
   - A. Tap—300 ppm hardness
   - B. De-mineralized
   - C. Distilled

Natural and colored high-density polyethylene coated panels were exposed in an Atlas Fadeometer. After 1200 hours ultra-violet light exposure, the coatings were unchanged. These tests are being continued.

The salt spray resistance of coated pipe samples is also being investigated. The exposure of the samples for 600 hours has not revealed any corrosion of the substrate. Edge undercutting did occur at the unprotected edges of the pipe during the first 100 hours exposure. The edge creep stopped. Rusting at pinholes has occurred but spreading has been almost nil.

The functional uses for the high-density polyethylene coatings were explored. An ice cube tray coated with 4 mils of polyethylene released the ice rapidly and cleanly after the water had frozen at 0°F for 16 hours. Static loads of 15,000 psi were applied to coated steel panels without delamination of the coating. The wear characteristics were determined on a Taber Abrader equipped with a coarse (H-22) abrader wheel or a smooth polished wheel and an 88 psi load. The wear was 1 mil/5,000 revolutions for the H-22 wheel and 1 mil/50,000 revolutions for the smooth wheel. These tests indicate that the coatings might be useful for lubricants, release agents and the like.

In addition to the laboratory tests, the high-density polyethylene coatings are being field tested on production equipment. A wash kettle cover, 4 feet in diameter, agitator and baffle were coated and have been in production service for a year. The previously used coating failed in less than three months in this corrosive atmosphere of methanol and hydrochloric acid. The coated cover protruded beyond the edge of the kettle and the coating was exposed to winter and summer weather without any apparent loss in adhesion.

The high density polyethylene coatings are also being field evaluated as coatings for water meter bottoms, motorboat propellers, trim molding, ice cube trays, steel containers etc. Preliminary reports have been very encouraging.

This is a preliminary report of investigations on Type III polyethylene as protective and functional coatings. It appears that through the use of these dispersions, solutions to old problems may be found. It is possible that many new application will be found for these polyethylene coatings.

Summary and Conclusions

A practical method for the application of high density polyethylene to metals has been described. This method has the following advantages:

1. Easily applied with conventional spray equipment.
2. Fused with conventional baking equipment.
3. Elimination of metal primers—polyethylene bonds to the metal.
4. Coating is all polyethylene—no foreign ingredients are present in the fused coating.
5. Easily colored to obtain tinted coatings.
6. Excellent resistance to chemicals and solvents.
7. Excellent non-wetting surface with a low coefficient of friction.

Ω

VHF PREHEATING for Thermosetting Molding

With the progressive improvements in design of equipment, particularly with respect to operating frequencies of 70-100 megacycles and high r.f. voltages, materials can be preheated to higher temperatures (270°-320°F) and successfully compression and plunger molded with reduced cycle time.

J. F. Trembley

W. T. LaRose and Associates, Inc.

DURING the past fifteen years considerable progress has been effected in development of electronic preheaters.

In the early periods of design, most preheaters were large complicated devices, complex as radio transmitters. Today, the direct opposite is true, simplicity of design, operation and rugged dependability in operation are the prime essentials.

Most preheaters in the early years, operated in the high frequency ranges, 5 to 30 megacycles, with low radio-frequency voltages which resulted in reduced preheating efficiency, particularly noticeable with mica-phenolic, urea, melamines, and other low-loss materials. Even today, 65% of all the preheaters in use operate at a frequency considered low, 15 to 30 megacycles.

Electronic preheaters are available which operate at frequencies between 70 to 80 megacycles, with high r.f. electrode voltages 8-20 K.V. This combination of frequency and voltage results in improved preheating efficiency of all thermosetting materials. There is a definite correlation between operating frequencies and material thermal conductivity. Generally, preheaters operating in the range of 70 to 80 megacycles will preheat thermosetting materials 30 to 40% faster and more uniformly, than preheaters operating in the 15 to 30 megacycle range. This fact is especially noticeable with low-loss materials.

With the development and application of V.H.F. high r.f. voltage preheaters, technological gains resulted and many changes were effected in standard operating procedures in the molding industry.

It has been learned that most general purpose materials can be rapidly preheated to temperatures of 270°-325°F and successfully compression- or plunger-molded.

By preheating to these elevated temperatures, radical cure cycle reductions have been effected, and molded properties improved physically and electrically.

To realize optimum efficiency in application of V.H.F. preheating, the following must be more specifically considered:

(1) Preheater K.W. output.
(2) Preheating cycles and temperatures.
(3) Preform density and shape.
(4) Material flow.
(5) Mold temperatures.
(6) Molding pressures for compression and plunger to effect faster cycles.
(7) Application techniques.
(8) Fully Automatic Molding and Preheating.

Preheater K.W. Output

For many years, preheater heatability requirements have been determined by accepted standards. A 1K.W. preheater will raise the temperature of approximately three-quarters pound of g.p. phenolic to 240°-250°F in sixty seconds.

Even today, most manufacturers' ratings are based on g.p. phenolic to 240°-250°F in sixty seconds, an obsolete standard. To realize optimum efficiency by preheating materials to higher temperature 270°-325°F, it is imperative that the average preheat be effected in thirty to forty seconds or less, otherwise the material resin would be reacted too far and precure will result. A general rule to follow in calculating electronic preheater capacity on g.p. phenolic to 300°F in thirty seconds, is to reduce the normal preheating capacity of 240°-250°F in sixty seconds by 65 to 70%.

Preheating Cycles and Temperatures

Most materials preheated to 250°-295°F are not reacted adversely with preheat cycles to 20 to 40 seconds. However, if materials are preheated to the maximum high temperatures 295°-325°F shorter preheat cycles should be used (10-20 seconds).

Presently most work in application of V.H.F. preheating to higher temperatures has been done with g.p. phenolics, and alpha-cellulose melamine.

Most molders using this technique in compression molding of g.p. phenolics on standard molding equipment are preheating to 290°-300°F; alpha-cellulose melamine to 260°-275°F. In plunger molding on standard equipment material temperatures for g.p. phenolic and melamine range between 250°-295°F.

Considerable improvement has resulted with V.H.F. preheating of urea materials for compression and plunger molding. The average material temperature range has been increased to 190°-230°F, with shorter preheat cycles (10 to 20 seconds); which has resulted in faster cures and improved product quality, particularly with respect to product appearance.

In most cases, the average maximum preheat cycles are not over thirty seconds. The other reason for application of the larger K.W. V.H.F. preheaters, with shorter preheat cycles is to comply with press cycles at the faster curves.

Preform Density and Shape

Another important consideration to achieve efficiency in application of V.H.F. electronic preheating is maximum density of all material preforms.

One of the most reliable and inexpensive test devices is a D scale durometer. Preform density should range between 70-85, average for most phenolics, melamines, and urea materials.

There is a definite correlation between rate of heat absorption and saturation temperatures according to preform density. To illustrate this: a preheating test was conducted in a 5 K.W. V.H.F. preheater. The six rectangular preforms standing on edge, 4" x 1½", 102 grams each, g.p. phenolic, measuring 75 D scale durometer were preheated uniformly to 300°F in 22 seconds. In the next test, four preforms measuring 75 D scale and two 55 D scale were preheated; after a 22 second preheat the two 55 D preforms measured 240°F, the four 75 D preforms 300°F, a 60°F variation due to differential density.

In further observation and evaluation, it has been noted, rectangular or square preforms are preferred over round preforms. Generally, rectangular or square preforms, can be preheated to higher temperatures than the same given material in the round preform state and successfully molded.

The reasons for preference of dense rectangular or square preforms in V.H.F. preheating are as follows:

(1) Rectangular or square preforms are preheated standing on edge, eliminating the problem of non-uniform height.

(2) Rectangular or square preforms standing on edge generally can be preheated to higher temperatures more uniformly than round preforms, because of increased electrical capacity and less contact area with the electrode.

An interesting fact is that very dense 70-85D scale durometer, round or rectangular preforms preheat non-uniformly in lower frequency 15-30 M.C. preheaters.

Mold Temperatures

With application of V.H.F. preheating most generally, mold temperatures can be increased on all materials, above existing standards. On g.p. phenolics, some molds are operating at 400°F; generally the average range is between 350°-395°F. On alpha-cellulose melamine for dinnerware, many molds are operating in production at 365°F.

Molding Pressures for Compression and Plunger To Effect Faster Cycles

For many years, it has been apparent in application of electronic preheating that molding and plunger pressure can be reduced approximately 50% in comparison to other preheating devices—steam, electric.

In application of V.H.F. preheating to higher temperatures 270°-325°F with fast cycles (10-30 seconds) further pressure reductions have resulted. In compression molding phenolics and melamine, materials have been successfully molded at less than 1000 psi. Conversely lower plasticity materials can be used with normal pressure to effect shorter cures.

Application of these same techniques in preheating for plunger molding has proven most satisfactory. With no change in operating procedures, other than application of V.H.F. preheating to the high temperature range; plunger cycles have been reduced 50-60%, in addition to shorter cure and improved product quality.

Another interesting fact, in that materials have improved plasticity, plunger cycles of 3, 4 and 5 seconds are possible without flashing the molds, whereas previously a 15-second plunger cycle was standard.

Alpha-cellulose melamine materials have been successfully plunger molded, in molds specifically designed for general purpose phenolics, with only slight increase in pressure required, with application of these newer techniques in preheating.

It is logical on the basis of information set forth previously, even further improvements can be effected with V.H.F. preheating in the various phases of molding, p.s.i. in compression and plunger; cure cycle reduction of 15% to 85% over existing standards, and improved product quality.

In observation of V.H.F. preheating, it has been noted that in 90% of the cases, the overall operation and product quality was improved substantially; with no further refinement in technology other than replacement of 15-30 M.C. preheaters with V.H.F. 70-80 M.C. machines.

New technology in application of V.H.F. preheating, has accomplished phenomenal results; g.p. phenolic sections of ½" to ¾" have been cured in 15 to 30 seconds; and alpha-cellulose melamine dinnerware, heavy duty, cured in 20 to 30 seconds to meet all council standards.

With progressive improvements in resin technology, mold design, molding presses and electronic preheating, we can predict an unlimited future for potential thermosetting applications on new horizons, in highly competitive markets.

Application Techniques

The new V.H.F. preheaters are versatile with respect to r.f. voltages, which is important in preheating conductive materials such as graphitized phenolic; the r.f. voltage can be reduced 50% without affecting normal K.W. output, which results in successful preheating without arcing or burning of materials with up to 25% graphite.

Another advantage of this versatility is termed dual-purpose preheating. Specifically, a V.H.F. pre-

heater can be utilized for conventional preheating of loose powder or preforms in compression or plunger molding and converted in a few minutes to accommodate loading boards, two-and-one-half times larger than the basic electrode size, for preforms or powder, in multi-cavity compression molding.

A device, which we term a capacitance plate can be utilized to improve molding efficiency in many cases. This is usually an aluminum or brass plate ⅛" thick and slightly larger in area than the material charge. The capacitance plate actually increases the voltage across the load and intensifies the field strength; a particular advantage in preheating round, soft preforms. Only through test can this efficiency be determined; in many cases, cures have been reduced 15-30 seconds by incorporating this device in the preheating and molding operation.

Single-ply glazed cardboard is also recommended in application of V.H.F. preheating, to prevent material build-up on the electrodes. Actually the use of cardboard, top and bottom of the material load, in many cases improves molding results by containing plasticizers, volatiles, etc. in the material, which would otherwise be evaporated during the preheat cycle.

V.H.F. preheaters are being applied in semi-automatic and fully-automatic molding and preheating many loose materials, g.p. phenolics, urea, melamine C.F.I.-M.F.I., alkyds, polyester-glass, diayll materials, etc. The containers used are usually silicone-fiberglass, high-density polyethylene or Teflon. Improved efficiency in preheating and molding is noted because of the combination of higher frequencies and higher r.f. voltages.

Material Flow

In applying V.H.F. preheating to higher temperatures in shorter cycles in most cases for either compression or plunger molding, materials of lower flow or plasticity can be used, which results in shorter cures.

On the basis of extensive field application, it has been determined that the combination of V.H.F. 70-80 M.C. with higher r.f. voltages, apparently does not react and advance thermosetting resins rapidly as in the lower megacycle preheaters. In other words, materials preheated to higher temperatures 270°-325°F with resin in the liquid state, has improved plasticity and longer flow duration at lower pressure, with less mold erosion problems than the same material preheated in a lower frequency machine.

At present, there is considerable exploratory work being done in investigation of V.H.F. preheating in the higher temperature range 290°-325°F on phenolics in the soft plasticity range of 14 to 18, to investigate rate of cure, physical and electrical properties vs. stiffer flow materials at lower temperatures. It has been learned that some of the present soft flow materials heated to the higher temperatures cure faster than stiffer flow materials at lower temperatures. The stiffer flow materials at elevated temperatures are pre-cured.

Fully Automatic Molding and Preheating

During the past several years, a continuing development has been in progress; the application of V.H.F. preheating loose material for fully automatic compression molding. At this present time, there are approximately one-hundred-and-fifty installations in the field on automatic presses from 50 to 450 T.

At present, there are several sizes of fully-automatic V.H.F. preheaters utilized on automatic molding presses, 5 K.W. to 20 K.W. output.

Application of automatic preheating loose material to 220°-300°F in fully-automatic molding, allows reduced cures of 50-85% or more, improved physical and electrical properties plus prolonged mold life; factors which have been established through years of experience in semi-automatic molding with electronic preheating.

One of the latest innovations in fully-automatic preheating is a positive knock-out and brushing assembly in the loader. This is a dual purpose device which enables higher temperature preheating; when the automatic loading board is in the dump position over the mold the knock-out insures the ejection of the heated material and cleans the container, preventing progressive material build-up. Overall operating efficiency of press cycles has been increased as much as 30%-50% with application of the knock-out and cleaning device.

Most molding material suppliers have modified their granulation specifications, for more efficient application of materials with fully automatic loose material preheaters. These materials have less fines and dust with particle size more specifically controlled in processing. There is no extra charge for this premium material, best suited for application of automatic preheaters.

More recently there has been considerable discussion of fully-automatic plunger molding, with automatic preform preheating. In one large installation by a proprietary molder, several automatic preform preheaters have been in operation approximately five years; they report phenomenal results and cost reduction.

Fully-automatic V.H.F. preform preheaters are basically the same in design as V.H.F. powder preheaters, the difference being in the feeder and transfer assemblies.

For general information the cost to own, operate and maintain a 5 K.W. fully automatic granular material or preform preheater would be approximately $.40-$.45 per hour.

In conclusion, we would like to review some of the more recent applications of V.H.F. electronic preheating equipment. In the thermosetting resin field, they are wood and paper laminates compression molded; premix material (wood-flour and powdered resin) high-bulk, low-density mix preheated in the loose state and compression molded, resinoid abrasive grinding or conditioning wheels hot or cold pressed. Cure cycle reductions of 50% to 85% have been affected by comparison to accepted processing techniques.

Many thermoplastic materials can be conditioned, preheated or dried to improve product quality and reduce processing cycles. Among these are materials such as styrene, polyethylene, acetate, buterate, vinyl, acrylic, polyproplene and Lexan. In addition to extruder and preplasticizing applications, considerable exploratory work is in process relative to compression and plunger molding the above mentioned materials.

This affords and approaches an entirely new conception in processing thermoplastic technology with respect to reduction of capitol equipment expenditure and processing costs.

The Principles of Rotary Molding

John C. Reib

The Rainville Company, Inc.

Cropp Press Sales

THE PRINCIPLE of automation by rotary motion has been accepted by automatic machine designers for many years. We are all familiar with multiple station, multiple operation machines operating fully automatically at high speeds. Probably the most common example of this is the soft drink bottling machines that can be seen operating unattended from the street of any fair-sized city. It would be difficult to imagine production rates of 750/min. bottles of "pop" without the aid of rotary motions. Six thousand glass bottles per hour were made possible as early as 1930 with eight-station rotary machines. Literally thousands of rotary machines are in use today, machining, soldering, welding, assembling, casting, filling, capping, and—molding plastics.

If one were to approach the users of these common machines and suggest that they group all their stations together in a single rectangle and perform their functions by a series of stop and go, up and down, forward and backward motions we would be laughed out of their engineering departments. Why have all that lost time in reciprocating motions when we can accomplish the job "on the fly" with a rotary?

In 1941, David Cropp, who had been designing high speed automatic machines for the incandescent light bulb and related industries, was handed a new project. He was to set up a fully automatic compression molding plant for large volume production of bottle caps and small electrical parts. The problem was further complicated by the requirement that the

This paper was presented at the Fifteenth Annual Technical Conference of SPE.

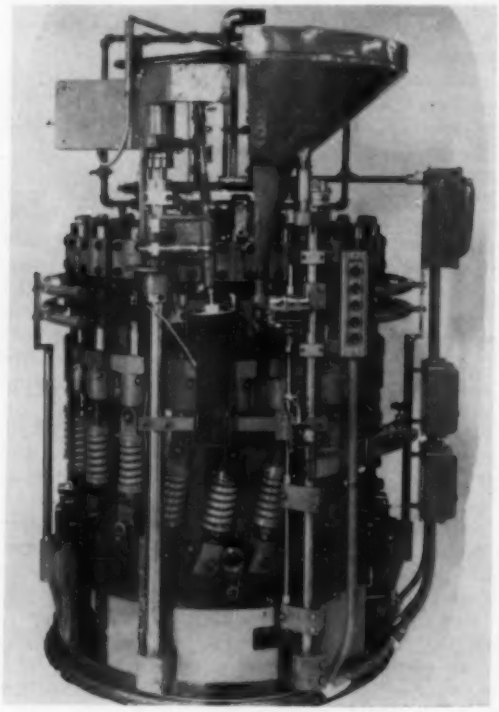


Figure 1.

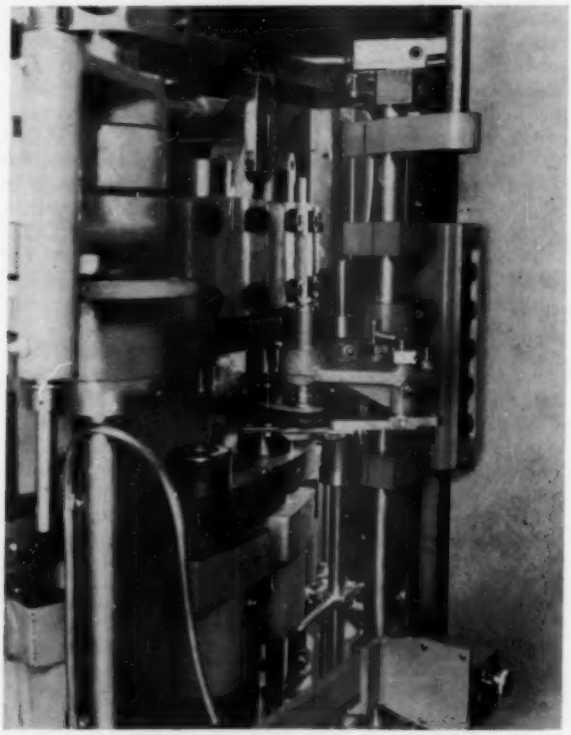


Figure 2.

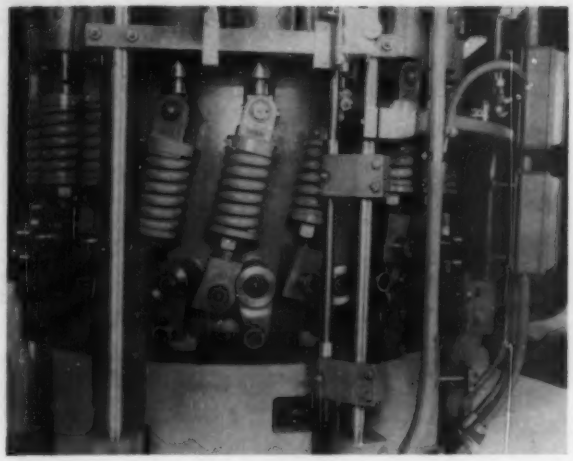


Figure 3.

equipment should be adaptable to molding of parts requiring top and bottom ejection and even reverse taper closures.

Some time later Mr. Cropp was operating several automatic rotary compression molding machines. These original three-ton-per-station, 20-station machines were fully mechanical in operation, were driven by a single ¾ HP motor and were heated by open gas flames playing on the mold platens. They have been variously described by non-users as a "rotary monstrosity," a "fire-ball" and a "thing that goes around a ring of fire spitting parts down a chute." Current users who watch twenty good parts being produced every 18 seconds on twenty sets of cores and cavities using fifty cents worth of electricity and $1.50 worth of natural gas per 24 hour a day can afford to sit back and overlook these comments.

The 3½-tons-per-station, 20-station mechanical press that is commercially available today is basically the same in principle as those original machines. There have, of course, been many refinements and improvements to provide the versatility and speed needed for a commercially saleable piece of equipment.

Fig. 1 shows the press tooled for a whiskey bottle cap that produced 3,000 pieces per hour. The 20 stations or "presses" are mounted on a rotary table which is in constant motion. This motion is counter clockwise or left to right as shown in this view. The unscrewing wheel just over the parts chute is mounted at an average thread helix angle and has an adjustable spring load for proper pressure against a threaded part.

Just to the left of the post supporting the unscrewing wheel mechanism is a station about to "break" or open as it starts into the opening cam at the base of the machine. As the cam followers move down this track, the toggle releases the spring pressure on the part and pulls the mold open.

For threaded parts this press is equipped with "twist rams" which cause the bottom platen and cavity to twist 15° as it initially opens. This, in effect, uses the cavity as a "wrench" to provide the initial "break" of the part from the force. The only function remaining for the unscrewing wheel is to "spin" the parts off the force so they can drop into the chute as the station passes. Without this feature, the unscrewing wheel would exert excessive pressures, thus

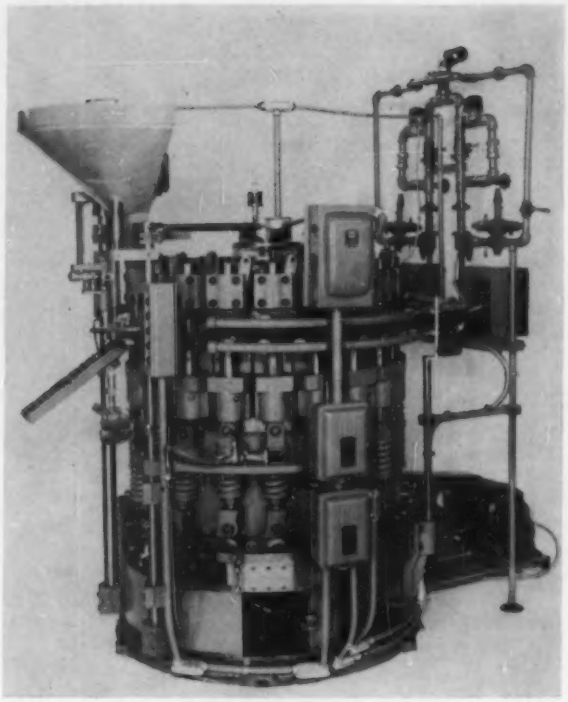


Figure 4.

marking the outside of the part and cause unnecessary wear on the wheel. As the part is removed, a burst of air removes loose flash and the station is ready to be loaded with powder.

A single bushing fed directly from the material hopper and powered by a cam under the press does the job. Fig. 2 shows this bushing directly under the force in its final "dump" position. (The powder hopper has been removed in this photo.) The powder bushing travels in an arc from the hopper to the mold and in its last 5/8" of travel is moving in the same direction and at the same speed as the mold. At this point the shutter is pulled and the powder is dropped into the cavity. This smoothly operating continuous motion offers a consistent and accurate powder feed to even very small, irregular shaped loading wells.

Fig. 3 shows a close up view of the patented toggle, power spring and adjustment nut, rams and the opening and closing cam or "track." Pressures can be adjusted on each station from 1½ tons to 3½ tons by a simple adjustment of a single nut. The closing cam shown in the view will provide a mold close as fast as less than one second for fast phenolics or alkyds. Slow closing cams can be substituted for ureas or melamines as required. If breathe or degassing is required a cam will provide it at any point in the first 1/3 of the cycle.

Fig. 4 shows the toggles as they have passed over the closing cam and have locked. These toggles actually go "over center" and lock so the cam followers do not ride or use power until coming in contact with the opening cam at the completion of the cycle.

The Selas radiant ceramic burners can be seen in this view, protruding around the curved gas manifolds around the periphery of the mold circle. The combination of the reflective principle and the massive design of the heat platens provides extremely uniform temperature control.

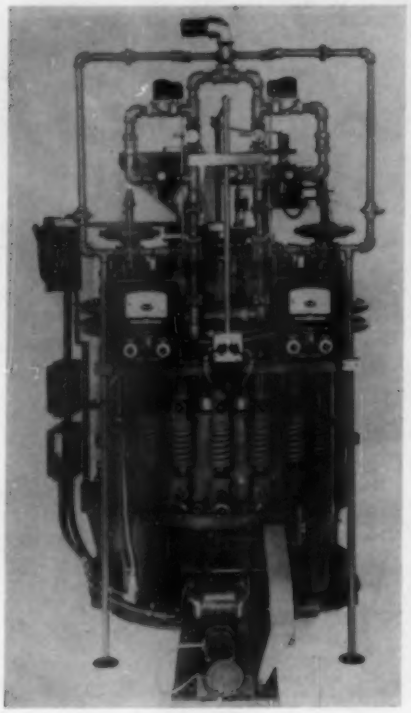


Figure 5.

A ¾ HP variable speed drive at the rear of the machine provides cycles of 15 to 90 seconds. Adjustment can be made with the machine in motion.

The air-gas mixing arrangement and heat controllers can be seen in Fig. 5. Natural gas is reduced to 0 pressure and high volume low pressure air is introduced at the top of the system. Gas is then drawn in by the venturi mixers in correct proportions to the air.

These Fenwal thermister type, on-off-proportional, controllers will hold final mold temperatures to within ±4° throughout the periphery of the press.

Fig. 6 is the birds-eye view showing the rugged construction of the "C" frame type individual press "heads". This solid construction is line bored to guarantee positive alignment of mold halves.

The slip rings or commutator system in the center transmits the signal from the thermister sensing elements in the moving molds to the stationary controllers. In actual operation these slip rings are covered by a dust-proof shroud which prevents accumulation of a film of dust that could cause controller deviation.

The basic concept of rotary molding is to achieve all the advantages of single cavity press operation and develop production rates exceeding other methods of automatic molding.

Let us compare some of the factors of single cavity operation versus multiple cavity operation on conventional flat bed press equipment.

1. *All* the press pressure is exerted on that one cavity consistently.
2. Precisely matched cavities are not required.
3. No platen distortion.
4. Loading is simple, accurate and consistent; a single loader bushing does the job.
5. Part removal is simplified.

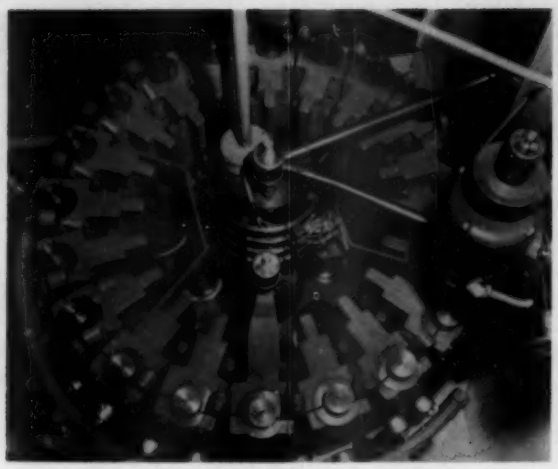


Figure 6.

6. Long, reciprocating motions of loading and unloading mechanisms are eliminated.
7. More uniform and consistent heat control.
8. *Eliminate* cost of mold bases, heating and ejector systems in the mold.
9. Flash removal is simple and more positive (it is not blown out of one cavity into another)

I'm sure we all agree that potential problems in any kind of molding are multiplied by the number of cavities in the mold. In fact, these problems have made semi-automatic operation necessary on many jobs that were planned for automatic operation.

Now, to develop the production desired. Take a quantity (in the press just discussed it was 20) of simple, single cavity presses and mount them on a constantly moving rotary table, pass them by the same common stationary heating system, load powder (or preforms) with a common, simple loader bushing and remove parts; all without stopping and starting.

Because all motions are timed mechanically you eliminate the problem of accuracy and maintenance of electrical timers.

In the press just described, there are three stations "open" or not curing at any one time. Therefore in this 20-station press approximately 17/20 of a total cycle is spent in actual cure of material under full pressure.

For an example of production cycles, take a conservative cross section of actual experiences. Our hypothetical job had been running previously on a flat bed press with an actual cure time of 21 seconds.

We know we can cut cure time by 15% to 40% by control of pressure on individual cavities, uniformity of heating and accurate powder loading. Let's choose a conservative 20% reduction in cure for a 17-second cure on the rotary. This means a 20-second total cycle or 60 parts-per-minute. *You* determine how that 3600 parts per hour compares to production from a much more costly 30 cavity mold based on the unproductive time of *your* press.

Thus far this discussion has been confined to the standard rotary press equipment and its common use of feeding cold powder. The recent advent of automatically feeding preheated powder has greatly increased the potential scope of rotary molding.

Presently, automatic equipment to continuously feed powder through a high frequency preheater to a

rotary is under construction. Initial experiments have shown tremendous increases in cycles.

This preheat equipment was designed to take advantage of the continuous operation of the rotary and obtain many of the advantages of preheated preforms without their additional handling cost. With this design cold powder is being continuously fed through a preheater and compressed to a semi-preform stage. This gives the economic advantage of preheated powder coupled with the physical advantages of preheated forms.

The development of automatic preheat on the rotary will produce the following advantages:

1. Lower molding pressures.
2. Better finish.
3. Shorter cures (the heavier the section the greater the percentage of production increases).
4. More uniform cure of cross-section.
5. Closer tolerances.
6. Longer mold life.
7. Reduction of gaseous vapors and moisture.

These advantages greatly increase the potential applications of rotary molding.

Now let us discuss recent developments and things to come in rotary presses. A revolutionary new development is a 10-station transfer press for polyester-premix materials. There are four of these presses now running producing electrical parts.

This equipment utilized the standard 3½ ton press with 10 heads removed. A transfer cylinder was mounted for side transferring of cold polyester-fiberglass premix to each station as it passes by. The transfer cylinder is simply indexed to each mold and moves with the mold until the transfer cycle is completed and then returns to pick up the next mold. The rotary transfer molding of polyesters has opened up an entire new field of possible applications for this material.

Another example of progress in rotary molding is the 8 ton-per-station, 20-station hydraulic press shown in Fig. 7. Three of these presses are now in use molding caster wheels up to 3" in diameter. This particular press utilizes preheated preforms, automatically transferred from an electronic preheater. This press can develop as much as 10 tons and can be built for feeding preheated preforms or powder.

Utilizing hydraulics on rotary presses has made possible vastly larger tonnages without greatly increasing press size. In the development of these larger hydraulic presses the basic simplicity of prior rotaries has been pursued. The simple patented four-way valving arrangement has eliminated complicated dual systems to achieve quick closing and high pressures when needed.

This same machine has been adapted to transfer molding of more conventional thermosetting materials such as phenolics, melamines, etc., which require higher transfer pressures.

Since we now have transfer molding on a rotary, let us now consider insert loading. Insert loading has always been the stumbling block to automating that type job on conventional equipment. Rotary presses provide individual molds passing by a given point or loading station so insert loading becomes greatly simplified. A repetitious simple motion of the loading mechanism provides more accurate handling of inserts.

Now that larger hydraulics are a reality, we can now envision whole new fields of application. Ten-

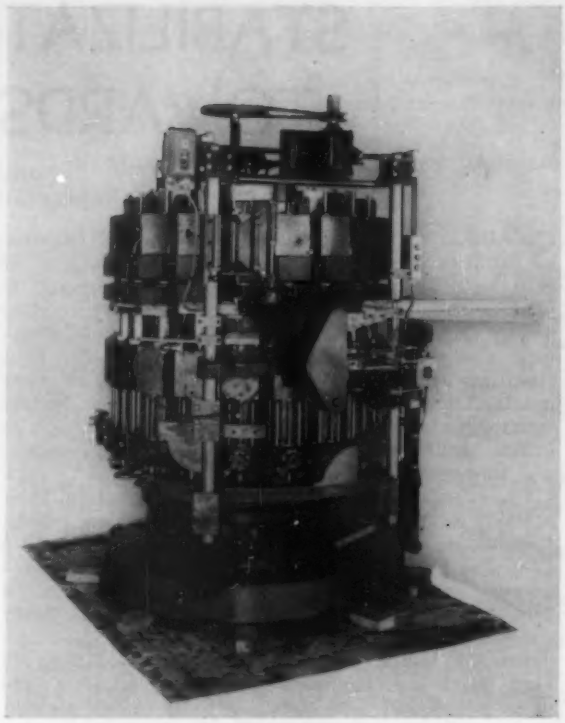


Figure 7.

station, 20 tons-per-station could easily be adapted to the same table and frame as the press shown in Fig. 7. With continuous feeding of preheated material and possibly top ram transfer and automatic insert loading one can visualize an entire new realm of applications.

Since a rotary press is a very high production piece of equipment we must search out high volume applications. This is no doubt the reason that rotary molding has been prevalent in the closure and electrical fields.

With the development of higher tonnage presses will come horizons unlimited. I'm thinking as an example of the fabulous dinnerware field. With the production required by that field it's not difficult to imagine a 10 station, 30 to 40 tons per station press, producing even small plates with the aid of preheated powder or preforms. Already preliminary design work is being done on the development of a simple core pulling arrangement for cups to take advantage of the continuous operation and eliminate expensive core pulling arrangements built into the mold.

In talking to many thermosetting molders we're given the impression that they have become convinced that their own is a dying industry. This is because of the inroads being made by new thermoplastic materials in the normal thermoset applications.

Let's not discuss ways to save that business. Instead let's think about creating an entirely new industry. If we can find a material that costs one-third to one-half as much and provide methods that will produce as fast or faster at the same capital equipment costs, haven't we found a new business? Certainly automatic continuous rotary molding with automatic electronic preheat can and will do just that.

Ω

STABILIZATION OF PVC TOWARDS SUNLIGHT

Norman L. Perry
Argus Chemical Corporation

STABILIZERS are included in polyvinyl chloride formulations to provide them with the degree of heat stability necessary for their processing and to provide sufficient light stability for the service conditions they are to undergo. Simple and rapid laboratory evaluation allows the selection of the best stabilizer combination to meet processing requirements. Through proper choice of stabilizer system components, other requirements may be met, such as sulfide stain protection, clarity, electrical properties and lubrication.

The effect of stabilizer choice upon light stability or outdoor weathering cannot be determined as readily. Various accelerated light aging devices have been (and are being) used to help predict a vinyl compound's service life when exposed to the elements. The results obtained from accelerated light aging equipment (Fadeometers, Weatherometers, sunlamps, germicidal lamps, etc.) are generally considered only very rough indications of the manner in which the vinyl compound will actually hold up in service. Even though most vinyl compounders realize the limitations of accelerated light aging tests, they find they must base many formulations upon such evidence since they cannot wait for one, two, or more years before actual weatherability of a compound is determined.

The availability of basic information as to the effect of formulation ingredients on outdoor aging would serve as an excellent guide to the formulator. In compounding for good weatherability, the formulation could include those materials which will provide good resistance to weathering and exclude those likely to be troublesome.

As part of a study aimed at the development of highly efficient heat and light stabilizers, many formulations have been exposed in Arizona for several years. As part of this program, the effect on light stability of many various vinyl compounding ingredients in use today were evaluated. Although this investigation primarily examined the effect on weatherability of components of barium-cadmium stabilizer systems, some study was also given to the role of resin, plasticizer, opacifiers, and auxiliary light stabilizers.

Major Stabilizer Types

Almost all vinyl compounds manufactured in the United States are stabilized with a system basically consisting of either barium-cadmium complexes, lead salts, or organic tin compounds. The choice of system type depends upon processing conditions, cost, and end use requirements.

Lead salts provide good heat stability at low to moderate cost. Vinyls stabilized with lead salts often have a tendency to color shift during processing so that the use of these materials is generally limited to applications where absolute color control is not necessary. Most vinyl insulation is presently stabilized with lead salts since lead stabilizers provide excellent electrical properties. Lead stabilizers are suitable for use only in opaque formulations although translucency is possible with certain lead silicates. Limitations to the use of lead stabilizers are their high degree of toxicity and their tendency to stain in the presence of sulfides.

The most important tin stabilizers are dibutyl tin dilaurate, dibutyl tin maleate, and dialkyl tin mercaptides. Most commercially available tin stabilizers are based on one or more of these three basic materials. All three can provide crystal clarity and freedom from sulfide stain. The prime limitations to the use of tin stabilizers are their high cost and the relative inefficiency of the non-mercaptide tin salts.

The dialkyl tin mercaptides provide outstanding heat stability and excellent clarity. They are often used for the stabilization of unplasticized vinyl compounds. The chief drawbacks to the mercaptides, which rule against their more widespread use as vinyl stabilizers, are their generally unpleasant odor and their tendency to cross-stain in the presence of any material containing a lead, cadmium, or other metallic salt which can form a colored sulfide.

Barium-cadmium stabilizer systems provide excellent heat stability at moderate cost. Through proper choice of components, crystal clarity and freedom from sulfide staining may be obtained. Excluding primary electrical insulation, the barium-cadmium complexes represent the most widely used type of vinyl stabilizer. A complete barium-cadmium stabilizer system includes an organic salt of each of these two metals, an organic phosphite, and an epoxy plasticizer or resin. All of these components are necessary for optimum performance. In addition, some formulations may require the use of organic zinc salts, specific lubricants, and antioxidants for best results.

Evaluation of Light Stability

Test sheets 6″ x 12″ x 0.030″ were prepared by fusing resin, plasticizer, stabilizer, etc. for five minutes at 320°F (160°C) on a two-roll mill. The sheets were exposed at the testing site of Desert Sunshine Exposure Tests, 7740 Ramona Road, Phoenix, Arizona.

Arizona was selected as the test site since incidence of natural sunshine at this location is very high. Results would therefore be available in the shortest possible time. In addition, the climate in Arizona is very arid. Thus, light stability results would not be complicated by such factors as plasticizer hydrolysis or fungicidal attack. While the latter factors are undoubtedly of importance in some types of vinyl failure, they should be studied independently of light degradation as far as possible.

Samples were exposed on racks, supported by aluminum frames, facing south at an angle of 45° from the horizontal. Except for one series of compounds, in which the effect of exposure under glass was investigated, the samples were exposed directly to sunlight.

One-inch by two-inch swatches of the compounds under test were returned monthly at first, then bi- or tri-monthly for examination. Four signs of degradation were evaluated: spotting, discoloration, stiffness, and tack formation. These factors were evaluated on a scale from 1 to 5 as follows:

1. No degradation
2. Slight degradation
3. Moderate degradation
4. Severe degradation
5. Very severe degradation

The first evidence of degradation on most of the compounds evaluated was development of randomly located brown spots. This was generally followed by dirt pickup on the surface—indicative of the formation of a tacky exudate. As exposure continued, the size and number of degraded spots increased until the compound became dark brown and stiff. In the tabulated results that follow the course of degradation is followed through the numerical system outlined above. The abbreviations used for forms of degradation at the top of each column are as follows:

S. Spotting
D. Discoloration
H. Stiffening (Hardening)
T. Tack Formation

The useable service life of a compound has been arbitrarily chosen as the length of exposure needed for moderate degradation (number 3) to occur by any mode of breakdown (*S, D, H,* or *T*), or for slight degradation (number 2) to occur in three of the above areas of measurement. Thus, if *S, D, H,* and *T* for a compound after exposure were reported as 3111, this would indicate moderate degradation by spotting and no signs of degradation due to discoloration of the base compound, stiffening, or tack formation. If a compound were reported as 2122 it would exhibit slight degradation by spotting, stiffening, and tack formation but there would be no sign of degradation by discoloration of the base compound. In either case, the compound would be considered sufficiently degraded to bar further normal use. For convenience, this point is identified by underlining in the tables that follow.

The degree of exposure of the vinyl samples has been reported in terms of both time (months) and energy (langlies). If ultraviolet radiation is taken as the prime cause of failure, reporting degradation as a function of energy (langlies) will result in greater reproducibility of results and better comparison between two samples exposed at different times. A langlie is defined as 1 gram-calorie/sq. cm.

Although exact correlation of the reported findings with similar vinyl compounds that may be exposed under other climatic conditions may not exist, it is believed that the conclusions reached will show the general factors necessary for optimum outdoor light stability.

Many of the stabilizers referred to below are complex combinations. The general chemical composition of these stabilizers is as follows:

Mark XI: Coprecipitated barium-cadmium laurate (metal ratio 3/2)
Mark XX: Tertiary organic phosphite (chelator)
Mark M: Liquid barium-cadmium organic stabilizer of phenate type containing a chelator
Mark WS: High cadmium content modified barium-cadmium laurate
Mark C: Modified tertiary organic phosphite
Mark XV: Liquid cadmium organic stabilizer with phosphite
Mark PL: Liquid zinc organic stabilizer with modifiers
Mark X: Alkyl tin mercaptide stabilizer

In all cases, stabilizer samples used were normal production materials.

Light Stabilizing Action of Barium-Cadmium Complexes

One of the first and most elementary barium-cadmium stabilizer systems consists of a coprecipitated barium-cadmium laurate, a tertiary phosphite stabilizer (chelator), and an epoxy plasticizer. The use of all these components results in a synergistic effect which provides far better heat stability than could be expected from the stabilizing influence of any one. A similar synergistic effect is found when light stability is investigated. This is shown in Table I which investigates the effectiveness of the various components of this system.

Comparison of the stability of compounds 1 and 2 indicates that the use of a phosphite stabilizer in conjunction with a barium-cadmium soap has a beneficial but relatively minor effect upon light stability. This is in contrast to the very major effect that a phosphite has upon heat stability, when used in conjunction with a barium-cadmium stabilizer.

Comparison of compounds 1 with 3 and 2 with 4 illustrates the importance of an epoxy plasticizer in providing good light stability. The effect of an epoxy plasticizer in extending heat stability has long been known; its beneficial effect in tripling or quadrupling light stability, when used with a barium-cadmium complex, is apparent from the above data.

The degradation behavior of compound 5, stabilized only with epoxy plasticizer, is of interest. Tack formation was evident early during the degradation, possibly due to formation of the incompatible chlorohydrin. Overall light stability of this compound was found to be about equivalent to that of compounds 1 and 2. Only when used with a barium-cadmium stabilizer can the full light stabilizing action of epoxy plasticizers be realized.

Comparison of Barium-Cadmium Systems

The stabilizer system outlined above was one of the first commercial barium-cadmium-phosphite systems and has now been largely replaced by more

Table I

Compound No.		1	2	3	4	5
Homopolymer Resin		100	100	100	100	100
DiOctyl Fthalate		50	50	45	45	45
Epoxy Plasticizer		—	—	5	5	5
Mark XI		2	2	2	2	—
Mark XX		1	—	1	—	—
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
1	20,700	1111	1111	1111	1111	1111
2	43,800	1111	2111	1111	1111	1112
3	67,100	2111	3111	1111	1111	1113
4	89,100	3111	3111	1111	1111	1213
5	108,000	3111	4221	1111	1111	2323
6	126,500	3111	4441	1111	1111	2332
8	152,700	4211	5441	1111	1111	2441
10	170,800	4311	5551	1111	1111	4541
12	200,900	5551	5551	2111	1311	4541
14	242,800	5551	5551	3112	4322	5551
16	283,100	5551	5551	4221	5551	5551
18	318,400	5551	5551	5551	5551	5551

Table II

Compound No.		6	7	8	9	3	10	11	12	1
Homopolymer Resin		100	100	100	100	100	100	100	100	100
DiOctyl Phthalate		45	45	45	45	45	50	50	50	50
Epoxy Plasticizer		5	5	5	5	5	—	—	—	—
Mark M		2	—	—	—	—	2	—	—	—
Mark WS		—	1.5	1.5	—	—	—	1.5	1.5	—
Mark C		—	—	0.5	—	—	—	—	0.5	—
Mark XV		—	—	—	3	—	—	—	—	—
Mark XI		—	—	—	—	2	—	—	—	2
Mark XX		—	—	—	—	1	—	—	—	1
Stearic Acid		0.5	—	—	0.25	—	0.5	—	—	—
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
1	20,700	1111	1111	1111	1111	1111	1111	1111	1111	1111
2	43,800	1111	1111	1111	1111	1111	1111	1111	1111	1111
3	67,200	1111	1111	1111	1111	1111	1111	2111	1111	2111
4	89,100	1111	1111	1111	1111	1111	1111	3111	2111	3111
5	108,000	1111	1111	1111	1112	1111	2111	4221	2111	3111
6	126,500	1111	1111	1111	1112	1111	2111	5541	3111	3111
8	152,700	1111	2221	1111	1212	1111	3211	5541	3111	4211
10	170,800	1111	2332	1111	1212	1111	4431	5551	4211	4311
12	200,900	1111	2432	1211	2222	2111	5531	5551	5321	5551
14	242,800	2112	5551	2432	3322	3112	5541	5551	4531	5551
16	283,100	3221	5551	5551	5551	4221	5551	5551	5551	5551
18	318,400	3231	5551	5551	5551	5551	5551	5551	5551	5551

efficient combinations. The light stabilizing action of different basic types of barium-cadmium stabilizers has been determined and the results are shown in Table II. Compounds 6, 7, 8, 9, and 3 compare five basic systems in the presence of an epoxy plasticizer, compounds 10, 11, 12 and 1 compare four basic stabilization systems in the absence of epoxy. The amount of stabilizer incorporated in each compound is the concentration that would generally be required for a normal calendering operation.

Of all barium-cadmium systems evaluated, Mark M provides the best protection against weathering damage. Mark M typifies the phenate type of liquid barium-cadmium-phosphite stabilizer that is very widely used in all types of vinyl processing.

Mark WS represents a high cadmium content modified barium-cadmium soap with outstanding heat stabilizing properties.

When used in combination with Mark C, it provides light stability that is approximately equivalent to that which can be obtained from the older Mark XI-Mark XX combination described previously.

The importance of an epoxy plasticizer in providing good light stability may again be seen through comparison of compound 6 with 10, 7 with 11, 8 with 12, and 3 with 1.

Comparison of Stabilizer Types

As was mentioned above, the three basic types of stabilizers in general use today are the lead salts, barium-cadmium complexes, and organic tin salts. The protection that typical systems of each type provide against outdoor weathering was determined by exposing a series of compounds as in Table III.

Compounds 6, 13, and 14 represent transparent formulations. Comparison of compounds 6 and 13 indicates that far better weathering protection is provided by a barium-cadmium-chelator epoxy system than by a combination of dibutyl tin dilaurate with an epoxy plasticizer. That epoxy plasticizers have a beneficial effect on weatherability is again demonstrated (compounds 13 and 14). With dibutyl tin dilaurate, however, the beneficial effect of epoxy is not nearly as pronounced as with barium-cadmium stabilizers (see Table I).

Table III

Compound No.		6	13	14	15	16
Homopolymer Resin		100	100	100	100	100
DiOctyl Phthalate		45	45	50	45	45
Epoxy Plasticizer		5	5	—	5	5
TiO_2		—	—	—	2	—
Mark M		2	—	—	2	—
Stearic Acid		0.5	—	—	0.5	—
Dibutyl Tin Dilaurate		—	2	2	—	—
Dibasic Lead Phosphite		—	—	—	—	3
Dibasic Lead Stearate		—	—	—	—	0.5
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
1	20,700	1111	1112	1111	1111	1111
2	43,800	1111	1112	1111	1111	1111
3	67,200	1111	1112	2111	1111	1111
4	89,100	1111	1111	2111	1111	1111
5	108,000	1111	1111	3111	1111	1111
6	126,500	1111	1111	4211	1111	1211
8	152,700	1111	2211	5431	1111	1211
10	170,800	1111	3211	5541	1111	1211
12	200,900	1111	4321	5551	1111	1211
14	242,800	2112	4431	5551	1111	1211
16	283,100	3221	5541	5551	1111	1211
18	318,400	3231	5551	5551	1111	1211

As pointed out previously, the use of lead stabilizers generally results in opaque compounds. As will be seen subsequently, opacification is a distinct aid to weatherability. Lead stabilized compounds should thus display reasonably good light stability. In comparing the light stabilizing action of lead salts with barium-cadmium complexes, the latter should be in an opaque compound. Compound 15, containing 2 phr Mark M, is identical to compound 6 except that it is opacified with 2 phr TiO_2. Compound 15 and lead stabilized compound 16 were both essentially satisfactory after 8 months' exposure.

Stabilizer Concentration and Thermal History

From the results presented above, it is evident that a barium-cadmium-phosphite-epoxy system represents a very efficient combination for achievement of optimum light stability in a vinyl compound. The concentrations of stabilizer compared above represent the quantities typically required for a normal plasticized calendering operation. A series of compounds was exposed to determine the effect of concentration of stabilizer constituents on weatherability, as in Table IV.

Comparison of compounds 17 and 18 indicates a very slight improvement in light stability as a result of doubling the concentration of metallic stabilizer. Similarly, comparing compounds 18, 19, and 20 indicates a relatively minor fall-off in light stability as epoxy content is decreased from five parts to one part. All four compounds, regardless of amount of epoxy plasticizer and barium-cadmium stabilizer, have approximately the same useable exposure life (18 months). However, as stabilizer content increases, the period of time before final degradation occurs is extended. It can be concluded that stabilizer content is relatively unimportant (at least within the concentrations tested) in the attainment of optimum light stability. As was found above, however, it is important that a combination of a barium-cadmium-phosphite system and an epoxy be employed.

Most of the compounds exposed depart from realistic vinyl end products in that the test formulations underwent only a minor heat history. As reported above, the test compounds were prepared by mill mixing for five minutes at about 320°F (160°C). Most vinyl products undergo a very much more severe heating cycle during processing. The effect of thermal history was evaluated by milling for varying lengths of time four compositions with the following basic recipe:

Homopolymer Resin	100
DiOctyl Phthalate	32.5
Epoxy Plasticizer	17.5
Mark M	3
Stearic Acid	0.5

Test specimens were prepared by milling individual batches of the above compounds for 5, 15, 30, and 60 minutes at 320°F (160°C). Exposure of these four samples indicated identical weathering characteristics.

It may thus be concluded that the degree of thermal history given the above compounds, like stabilizer concentration, has little effect upon weatherability. The best guide for formulating a compound to give optimum weatherability is to include a barium-cadmium stabilizer system in combination with an epoxy plasticizer, in the amount necessary to give the degree of heat stability required for processing.

Effect of Epoxy Plasticizer Type

The two types of epoxy plasticizers most widely used today are the epoxidized natural triglycerides (e.g. epoxidized soya oils) and the alkyl epoxy stearates. The type of epoxy plasticizer chosen is generally dependent upon the specific plasticizing properties desired. For example, the alkyl epoxy stearates will improve a compound's low temperature flexibility and may be used in place of aliphatic diesters (such as adipates, azelates, and sebacates) for this purpose. The epoxidized triglycerides exhibit poor low temperature performance but are superior to the alkyl epoxy stearates in resistance to extraction by greases or oils. Thus, they are preferred for applications requiring polymeric properties.

Table IV

Compound No.		17	18	19	20
Homopolymer Resin		100	100	100	100
DiOctyl Phthalate		45	45	48	49
Epoxy Plasticizer		5	5	2	1
Mark M		1.5	3	3	3
Stearic Acid		0.5	0.5	0.5	0.5
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
1	22,800	1111	1111	1111	1111
3	63,200	1111	1111	1111	1111
5	98,400	1111	1111	1111	1111
7	122,900	1111	1111	1111	1111
9	142,700	1111	1111	1111	1111
12	189,000	1111	1111	1111	1111
15	236,200	1221	1211	1211	1211
18	285,400	3321	2321	2321	2321
21	315,200	4441	2321	3321	3321
24	361,300	5551	2321	3321	4331

The two most important properties characterizing an epoxy plasticizer are its oxirane oxygen content (epoxy value) and its iodine value (degree of residual unsaturation). An epoxy plasticizer's iodine value is indicative of the material's aging compatibility in a vinyl compound. Epoxy plasticizers with high residual iodine values will generally exude upon several months aging in subdued light. The simultaneous presence of an epoxide and an unsaturated material in a vinyl compound evidently leads to the formation of an incompatible by-product. Low iodine value epoxy plasticizers will not exude due to aging incompatibility but will very markedly extend a vinyl compound's heat and light stability (See Table I).

Most commercially available epoxidized triglycerides have an oxirane oxygen content of approximately 6.0%. Alkyl epoxy stearates have epoxy values ranging from 3.1 to 4.5%. Even though there is an appreciable difference in oxirane oxygen content between the two types, there is surprisingly little difference in the degree of light stability imparted.

The results obtained in the evaluation of type and amount of epoxy plasticizer are shown in Table V. The epoxy plasticizers are commercial materials of low iodine value.

Effect of Auxiliary Heat Stabilizers

In addition to a barium-cadmium combination and an epoxy plasticizer, many vinyl formulations contain auxiliary heat stabilizers (such as zinc organics) and lubricants specifically required for optimum heat stability (such as stearic acid with phenate type stabilizer).

Inclusion or exclusion of organic zinc stabilizer (Mark PL) or stearic acid with a Mark M—epoxy plasticizer system was found to have no observable effect upon weathering stability.

Opacifiers

Most vinyl compounds contain fillers and pigments which, in addition to performing their primary function, may opacify the product. As with other components of a vinyl formulation, an opacifier may have either an adverse or beneficial effect upon light stability. It is quite logical to assume that an opacifier should inhibit light degradation by screening out the

Table V

Compound No.			21	22	23	24	25	26
Homopolymer Resin			100	100	100	100	100	100
DiOctyl Phthalate			45	45	48	48	49	49
Epoxidized Soya Oil (oxirane oxygen 6.0%)			5	—	2	—	1	—
Octyl Epoxy Stearate (oxirane oxygen 4.4%)			—	5	—	2	—	1
Mark M			2.5	2.5	2.5	2.5	2.5	2.5
Mark PL			0.5	0.5	0.5	0.5	0.5	0.5
Stearic Acid			0.5	0.5	0.5	0.5	0.5	0.5
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
1	22,800	1111	1111	1111	1111	1111	1111	1111
3	63,200	1111	1111	1111	1111	1111	1111	1111
5	98,400	1111	1111	1111	1111	1111	1111	1111
7	122,900	1111	1111	1111	1111	1111	1111	1111
9	142,700	1111	1111	1111	1111	1111	1111	1111
12	189,000	1111	1111	1111	1111	1111	1111	1111
15	236,200	1211	1211	1211	1211	1211	1211	1211
18	285,400	1321	2321	2321	2321	2321	3321	3321
21	315,200	2321	2321	3321	3321	3321	4321	4321
24	361,300	2321	3421	3321	3321	4331	5441	5441

harmful ultraviolet rays and most opacifiers do act in this way.*

In those cases where an opacifier has an apparent adverse effect on weatherability, consideration must be given to the possibility that the opacifier, or an impurity, may be acting as a degradation catalyst. Such a catalyst could overcome the beneficial effect of opacification.

It goes without saying that the opacifier employed should be at least as stable towards light as the base vinyl compound. Failure to recognize this fact, however, has resulted in considerable confusion: vinyl compounders have assumed that the basic formulation is at fault rather than the pigment or filler.

Probably the most widely used pigment in vinyl compounding is rutile titanium dioxide. It is the base of most white and pastel compounds and is included in many darker formulations as well. The effect of titanium dioxide upon light stability was determined by preparing five compounds which contained, respectively, 0, 0.25, 0.5, 1.0, and 5.0 phr of TiO_2. The following basic formulation was employed:

Homopolymer Resin	100
DOP	32.5
Octyl Epoxy Stearate	17.5
Mark M	3.0
Stearic Acid	0.5

After 12 months' exposure, all compounds were completely satisfactory, with no signs of degradation being evident. After 15 months, the unpigmented compound showed signs of slight stiffening and exudation. The unpigmented sample was badly discolored after 21 months and was completely degraded (dark brown and brittle) after 24 months' exposure. The compound pigmented with 5 phr titanium dioxide showed no signs of degradation for 24 months; at 27 months slight exudation was evident. Very little stiffening of this highly pigmented compound occurred during 27 months of continual aging.

Those compounds containing smaller amounts of titanium dioxide did show more serious signs of degradation after 27 months. That compound containing only 0.25 phr TiO_2 had stiffened considerably and showed a considerable amount of surface dirt (indicative of tack formation). It was noted, however, that degradation seemed to occur only on the surface exposed to light; the bottom surface was still clean and dry. Those compounds containing 0.5 and 1.0 phr of TiO_2 showed proportionately less degradation than a compound with 0.25 phr TiO_2.

Incorporation of 0.25 phr TiO_2 served to extend outdoor life in Arizona by approximately 6 months; 5 phr extended outdoor life by at least one year.

Effect of Auxiliary Light Stabilizers

It was seen above that the barium-cadmium-phosphite-epoxy combination allows 12 to 18 months of weathering of an unpigmented formulation in Arizona without any signs of degradation. Attempts to extend this life through adjustment of type and amount of heat stabilizer have not proven successful.

It has been found, however, that certain other materials may act specifically as light stabilizers for vinyls. When added to a normal barium-cadmium-epoxy stabilized composition, they will very markedly extend light stability. The beneficial effect of sodium organic phosphates, for example, in improving light stability is well known. These compounds, however, have such an adverse effect upon heat stability that their use is limited. Substituted benzophenones, even in very small quantities, have an extremely salutory effect on weathering properties and do not interfere with heat stability. The results shown in Table VI illustrate the effect of such an ultraviolet absorber (2-hydroxy-4-methoxy benzophenone) on light stability.

Addition of as little as 0.1 phr of 2-hydroxy-4-methoxy benzophenone to a normal barium-cadmium-chelator-epoxy system serves to extend stability appreciably. Similar compounds containing higher concentrations of ultraviolet absorber are presently being aged in Arizona to determine ultimate life of a clear compound. Other types of absorbers are also being evaluated.

Comparison of compounds 30 and 31 indicates the importance of using a complete barium-cadmium-chelator system with an ultraviolet absorber if maximum efficiency is desired. Addition of ultraviolet absorber to Mark XI provides about the same degree of weathering protection as does a barium-cadmium-phosphite-epoxy combination. Addition of chelator Mark C to this system significantly improves the stabilizing action of the light screening additive. This may be due to the antioxidant function of the Mark C which inhibits oxidation of the ultraviolet

* "Weathering of Polyvinyl chloride", De Coste and Wallder, Ind. Eng. Chem., Vol. 47, pp. 314-322, Feb. 1955.

Table VI

Compound No.		27	28	29	30	31	32
Homopolymer Resin		100	100	100	100	100	100
DiOctyl Phthalate		45	45	50	50	50	45
Octyl Epoxy Stearate (Drapex 4.4)		5	5	—	—	—	5
Mark M		1.0	1.0	—	—	—	—
Mark C		0.5	0.5	—	—	1.0	1.0
Stearic Acid		0.3	0.3	—	—	—	—
Mark XI		—	—	2.0	2.0	2.0	2.0
2-hydroxy-4-methoxy benzophenone		—	0.1	—	0.5	0.5	0.5
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
2	33,200	1111	1111	1111	1111	1211	1211
4	63,900	1111	1111	4413	1111	1111	1111
6	98,000	1111	1111	4431	1111	1111	1111
8	128,200	1111	1111	5541	1111	1111	1111
10	157,900	1111	1111	5541	1111	1111	1111
12	187,400	2111	1111	5551	2311	1111	1111
14	219,100	2212	1112	5551	2312	1111	1111
16	251,600	2312	1112	5551	2411	1111	1111
18	286,300	5531	1112	5551	2531	1111	1111

Table VII

Compound No.		33	34	35	36	37	38	39	40
Plastisol Resin		100	100	100	100	100	100	100	100
DiOctyl Phthalate		70	70	65	65	60	65	65	60
Octyl Epoxy Stearate		—	—	5	5	5	5	5	5
Octyl Diphenyl Phosphate		—	—	—	—	5	—	—	5
Mark M		2	2	2	2	2	2	2	2
Mark PL		1	1	1	1	1	1	1	1
Mark C		—	1	—	1	1	—	1	1
2-hydroxy-4-methoxy benzophenone		—	—	—	—	—	0.2	0.2	0.2
Months	**Langlies**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**	**SDHT**
2	33,200	1111	1111	1111	1111	1111	1111	1111	1111
4	63,900	2111	2111	1111	1111	1111	1111	1111	1111
6	98,000	3112	3112	1111	1111	1111	1111	1111	1111
8	128,200	4313	3112	1111	1111	1111	1111	1111	1111
10	157,900	4524	4113	1112	1111	—	1111	1111	1111
12	187,400	5535	5555	2113	1113	2113	1111	1111	1111
14	219,100	5535	5555	2324	2324	2424	1113	1112	1111
16	251,600	5542	5542	3425	3425	4533	1113	1112	1111
18	286,300	5552	5552	3433	3433	5552	1113	1112	1111

absorber. Further exposure is necessary to differentiate between compounds 31 and 32 (effect of epoxy).

Plastisols

In general, the same results detailed above were found with plastisol formulations. The prime difference between the emulsion polymerized plastisol resins and the suspension polymerized resins studied above is the presence of fairly large amounts of surface active agents in the former. A second difference is the higher plasticizer content usually associated with plastisol formulations.

The results obtained with plastisol resins are strikingly similar to those obtained with suspension polymers. The beneficial effect of epoxy plasticizer and an ultraviolet absorber are both seen. Some beneficial effect apparently also results when a small quantity of octyl diphenyl phosphate is included as a plasticizer in combination with Mark M, Mark PL, Mark C, epoxy plasticizer, and an ultraviolet absorber.

Exposure Under Glass

Many products made of vinyl are not subject to direct sunlight. Products such as draperies and automotive upholstery are subject to light which must first pass through glass. Thus, the effect of glass in modifying ultraviolet breakdown was deemed of interest. A series of compounds exposed under glass indicated no untoward departure from the results obtained by direct exposure except for the time needed for breakdown. Exposure behind glass increased the service life of a vinyl compound approximately twofold.

Conclusions

A complete barium-cadmium-phosphite-epoxy combination will provide a vinyl compound with excellent resistance to the degrading effect of sunlight. The degree of protection afforded by such a system is sufficient for most vinyl applications. For those applications requiring still better weathering resistance, the addition of small amounts of an ultraviolet absorber to the complete stabilizer combination will provide significant improvement.

Using such techniques, vinyl compositions can be formulated so that they are among the most resistant of plastics to outdoor aging.

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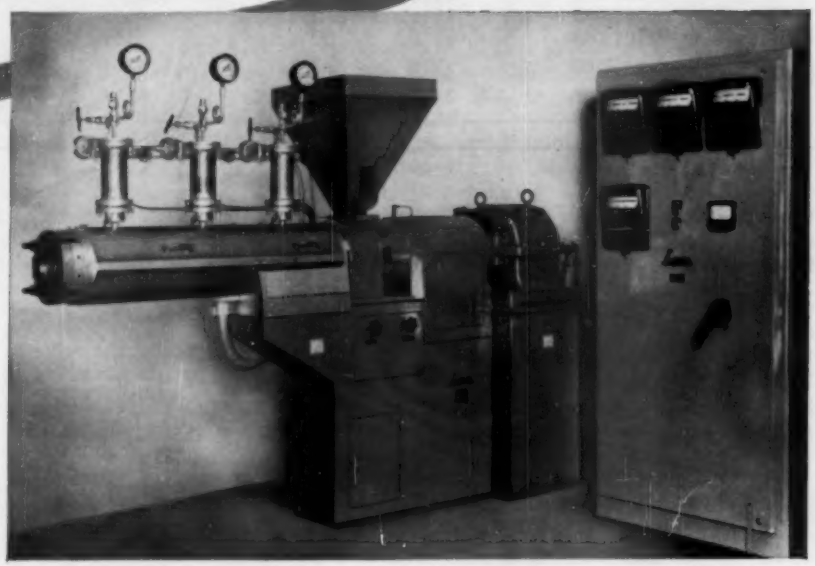

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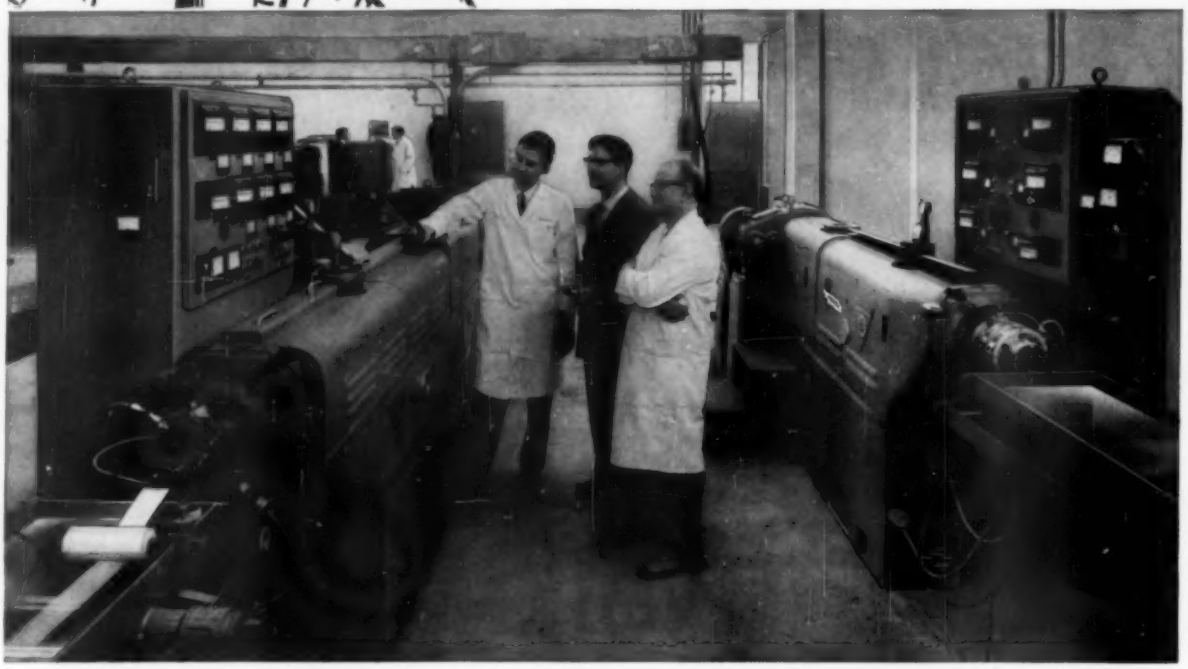

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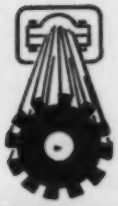

Edited by **B. H. Maddock**
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EXTRUSION BIBLIOGRAPHY

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IN ORDER TO ORGANIZE and facilitate review of the available literature on extrusion and allied subjects, a bibliography has been prepared by the PAG on Extrusion. References have been classified under two general headings, "Extrusion Theory and Analysis" and "Extruder Design and Application" and include only papers which have been published in recognized technical journals and books. The listings are undoubtedly incomplete and we would therefore appreciate being advised of any titles which have been missed so that they can be included in future publications. Reprints of many of the articles are available from the authors and it is believed that photostatic copies of almost all could be obtained from the New York Public Library.

A third section is planned which will be comprised of technical literature on extrusion issued as commercial publications by industrial organizations. Companies having such literature available are urged to forward a list of titles to L. F. Street, c/o Welding Engineers, Inc., Box 391, Norristown, Pennsylvania.

BIBLIOGRAPHY—Extrusion Theory and Analysis

"Sur l'Influence des Frottements dans les Mouvements Reguliers des Fluids," *J. mathematique pures et appliquees,* series 2, 13, 377, M. J. Boussinesq, 1868.

"Screw Viscosity Pumps", H. S. Rowell and D. Finlayson, *Engineering,* November 17, 1922, and August 31, 1928.

"Charts For Estimating Temperature Distribution in Heating or Cooling Solid Shapes", H. P. Gurney and J. Lurie, *Ind. & Eng. Chem.*, November 1923.

"Screw Viscosity Pumps", H. S. Rowell and D. Finlayson, *Engineering,* 114, 606—1922; 126, 249,—1928.

"Mechanical Principles of the Screw Extrusion Machine", Z. Rogowsky, Inst. of Mech. Eng., London, March 1945.

"On the Extrusion of a Very Viscous Liquid", Herschel Weil, *Journal of Applied Mechanics,* September 1951.

"Problems of Mixing in Extrusion", D. Grant and W. Walker; *Plastics Progress,* pp. 245-253, Iliffe & Sons, Ltd., P. Morgan, 1951.

"Pressures Developed by Viscous Materials in the Screw Extrusion Machine", W. T. Pigott, *Trans. ASME, 73,* 947—1951.

"Flow of Polystyrene Through Rectangular Channels", C. E. Beyer and F. E. Towsley, *J. Colloid Sci. 7,* 236—1952.

"Extrusion of *Plastics, Rubber and Metals",* H. R. Simonds, A. J. Weith, W. Schack, Reinhold Publishing Corp., N.Y., 1952.

"The Theory of Screw Extruders", R. A. Strub, Proc. Second Midwestern Conference of Fluid Mechanics, Ohio State University, pp. 481-494, 1952.

"Operating Characteristics of Extruders", J. F. Carley—*SPE Journal 9,* 9, March 1953.

"Principles of Plastic Screw Extrusion", W. L. Gore, *SPE Journal 9,* 6, March 1953.

"Design of Screws for Polyethylene Extrusion", J. M. McKelvey, *SPE Journal 9,* 12, March 1953.

"Plastic Flow Paths in an Extruder Worm", L. F. Street, *Modern Plastics,* April 1953.

"Strangpressen", H. Beck, *Kunststoffe,* January 1953.

"The Flow of Plastic Melts Through Dies", J. P. Tordella, *SPE Journal,* May, 1953.

"Extruder Scale-Up Theory and Experiments", J. F. Carley and J. M. McKelvey, *Ind. Eng. Chem. 45,* 989, 1953.

"Simplified Flow Theory for Screw Extruders", J. F. Carley and R. S. Mallouk and J. M. McKelvey, *Ind. Eng. Chem. 45,* 974, 1953.

"Some Aspects of the Screw Extrusion of Thermoplastics", J. E. Atkinson and D. G. Owen, *Trans. Plastics Inst.,* (London) *21,* 40 (1953).

"Basic Concepts of Extrusion", J. F. Carley and R. A. Strub, *Ind. Eng. Chem. 45,* 970, 1953.

"Future Extrusion Studies", C. H. Jepson, *Ind. Eng. Chem. 45,* 992, 1953.

"Experimental Studies of Melt Extrusion", J. M. McKelvey, *Ind. Eng. Chem. 45,* 982, 1953.

"Power Requirements of Melt Extruders", R. S. Mallouk and J. M. McKelvey, *Ind. Eng. Chem. 45,* 987, 1953.

"Adiabatic Extrusion of Polyethylene", J. M. McKelvey and E. C. Bernhardt, *SPE Journal,* March, 1954.

"Flow of Melts in Crosshead-Slit Dies; Criteria for Die Design", J. F. Carley, *J. Appl. Phys. 25,* 1118, 1954.

"Analysis of Adiabtatic Plastics Extrusion", J. M. McKelvey, *Ind. Eng. Chem. 46,* 660, 1954.

"An Analytical Study of the Single Screw Extruder", C. Maillefer, *Brit. Plastics 27,* 394, 437, 1954.

"Screw Extrusion Processes for Forming Plastic Materials", Y. Mori, N. Ototake and H. Igarshi, *Chem. Eng.* (Tokyo) *18,* 221 (In Japanese), 1954.

"Calculating Extruder Perform-

ance", E. C. Bernhardt, *Modern Plastics*, February, 1955.
"Viscous Heat Effects in the Extrusion of Molten Plastics", R. B. Bird, *SPE Journal 11*, 35, 1955.
"Theory of the Flow of Material in Worm Machines, Part I", W. Meskat, *Kunststoffe 45*, 87 (In German), 1955.
"Mechanism of Flow Through a Compression-Type Screw Extruder", Y. Mori and N. Ototake, *Chem. Eng.* (Tokyo 19, 9 (In Japanese), 1955.
"A New Development in Extraction-Extrusion—The Vacuum Extruder Screw", E. C. Bernhardt, *SPE Journal 12*, 40, March 1956.
"Solids Conveying in Extruders", W. H. Darnell and E. A. J. Mohl, *SPE Journal*, April 1956.
"Fundamental Mechanisms in Polyethylene Extrusion", B. H. Maddock, *SPE Journal*, October, November 1956.
"Design and Operation of Crosshead Sheeting Dies", J. F. Carley, *Modern Plastics 33*, 127, August 1956.
"Practical Experiences with Twin Screw Extruders and Their Utilization in Structural Design", Karl Tanner, *Kunststoffe*, September 1956.
"Viscosity Data for Extruder Flow Equations", R. D. Sackett, *SPE Journal 12*, 32, October 1956.
"Multi-Screw Extruders", K. Baigent, *Trans. Plastics Inst.* (London) *24*, 134, 1956.
"Modern Views on Extrusion Machinery", E. G. Fisher, *Trans. Plastics Inst.* (London) *24*, 143, 1956.
"Single Screw Extruders", E. G. Fisher, *Trans. Plastics Inst.* (London) *24*, 125, 1956.
"Autogenous Extrusion", A. N. Gray, *Rubber Age*, (N.Y.) *79*, 286, 1956.
"Viscous Flow Theory; I, Laminar Flow", Pai, Shih-I, Princeton, N. J., D. Van Nostrand Co., Inc., 1956.
"The Energy Equation for Viscous Flow", H. L. Toor. *Ind. Eng. Chem. 48*, 922, 1956.
"Melt Fracture—Extrudate Roughness in Plastics Extrusion", J. P. Tordella, *SPE Journal 12*, 36, 1956.
"Problems in the Selection of Extruder Screws", R. D. Sackett, *SPE Journal*, June, 1957.
"Extrusion Equipment", H. M. Whitcut, *Rubber and Plastics Age*, p. 56, 1957.
"Rheological Properties of Plastics", Arnold C. Werner, *Modern Plastics*, February 1957.
"Bulk Compressibility of Polymers at Fabricating Temperatures", B. Maxwell and S. Matsuoka, *SPE Journal*, February 1957.
"Valved Extrusion", E. C. Bernhardt, *SPE Journal 13*, February 1957.
"Factors Affecting Quality in Polyethylene Extrusion", B. H. Maddock, *Modern Plastics 34*, 123, April 1957.
"Flow Behavior and Turbulence in Polyethylene", R. F. Westover and Bryce Maxwell, *SPE Journal*, August 1957.
"Theoretical Extrusion Studies", J. M. McKelvey, *SPE Journal*, October 1957.
"Mixing in Laminar-Flow Systems", W. D. Mohr, R. L. Saxton and C. H. Jepson, *Ind. Eng. Chem.*, November 1957.
"Theory of Mixing in the Single Screw Extruder", W. D. Mohr, R. L. Saxton and C. H. Jepson, *Ind. & Eng. Chem.*, November 1957.
"End Correction in the Capillary Flow of Polyethylene", E. B. Bagley, *J. Appl. Phys. 28*, 624, 1957.
"High Speed Screw Type Extruders", E. Beck, *Kunststoffe 46*, 18, 1956; "Extrusion With High Speed Screws", *Kunststoffe 47*, 250, 1957; "Practical Experiences in the Case of Extrusion With High Speed Self-Regulating Screws", *Plastverabeiter 1*, 19, 1957 (All In German).
"Applications of Extrusion Theory", R. E. Colewell, Presented at the 13th Ann. Nat. Tech. Conference of SPE, *Tech. Papers 3*, 15, January 1957.
"Extrusion Coloring Natural Polyethylene", H. Segal, *SPE Journal*, December 1957.
"Nonisothermal Flow of Viscous Non-Newtonian Fluids", R. E. Gee and J. B. Lyon, *Ind. Eng. Chem. 49*, 956, 1957.
"Extrusion Problems and Screw Design in Polythene", A. Kennaway and D. J. Weeks, Renfrew, A. and Morgan P. (eds.) pp. 285-305 (London) Iliffe & Sons, Ltd., 1957.
"How to Predict Extruder Performance With Polyethylene", B. H. Maddock, *Plastics Tech. 3*, 385, 1957.
"Hydrodynamic Theory for the Flow of a Viscous Fluid", Y. H. Pao, *J. Appl. Phys. 28*, 591, 1957.
"Principles of the Screw Extrusion Machine", Z. Rogowsky (now Z. Rigby), *Engineering 162*, 358, 1956; also *Proc. Inst. Mech. Engrs.* (London) *156*, 56, 1957.
"A Method for Graphical Representation of Screw Characteristics", T. Yoshida, K. Hayashida, K. Kobayashi and H. Tenaka, *Chem. Eng.* (Tokyo) *21*, 366 (In Japanese), 1957.
"High Speed Screw Type Extruders-New Considerations", E. Beck, *Kunststoffe 5*, 1957, (also *SPE Journal*, June 1958.)
"Heat Generation and Expansion Effects in the Rheology and Molding of Plastics", H. L. Toor, *SPE Journal*, January 1958.
"Extrusion Machines by Boundary Layer Breakdown", Ernesto Gabrielli, 1958.
"Intensive Mixing, W. R. Bolen and R. E. Colwell", *SPE Journal*, August 1958.
"Power and Heat Energy Relations in Polyethylene Extrusion", B. H. Maddock, SPE ANTEC, January 1958.
"Some Aids to the Design of Dies for Plastic Extrusion, Part I", D. J. Weeks, Ph.D, April 1958.
"Some Aids to the Design of Dies for Plastic Extrusion, Part II", D. J. Weeks, Ph.D, *Brit. Plastics 31*, 201, May 1958.
"Screw Extruder Pumping Efficiency", P. H. Squires, *SPE Journal 14*, 24, May 1958.
"Experimental Determination of Velocity Profiles in an Extruder Screw", Silvio Eccher and Aldo Valentinotti, *Ind. Eng. Chem. 50*, 829, 1958.
"Some Aspects of Extrusion Die Design", E. G. Fisher and W. A. Maslen, *Brit. Plastics*, July 1958.
"Problems in Predicting Screw Performance", L. D. Barr, *SPE Journal*, September 1958.
"Controlled Pressure (Valve) Extrusion", B. H. Maddock, H. J. Nalepe, B. Zurkoff, *Rubber & Plastics*, December 1958; *Wire and Wire Products*, June 1958.
"Autothermal and Conventional Single Screw Extruder for Processing Plastics, Part I", G. Schenkel, *Kunststoffe*, November 1958.
"Important Advances in Extrusion Technology", R. D. Sackett and E. H. Hankey, *SPE Journal*, November 1957.
"Autothermal and Conventional Single Screw Extruders for Plastic Processing, Part II", G. Schenkel, *Kunststoffe*, December 1958.
"Extrusion of Plastics", E. G. Fisher, Iliffe & Sons, Ltd. (London), 1958.
"Non-Newtonian Flow in Annuli", A. G. Frederickson and R. B.

Bird, *Ind. Eng. Chem. 50*, 347, 1958.
"Theory of Screw Extruders, Vol. III", W. L. Gore and J. M. McKelvey; Rheology; Theory and Application, F. R. Eirich (ed.) N. Y. Academic Press, Inc. to be Published in 1958.
"Extrusion Theory", H. M. Hulburt, S. Katz and L. F. Street, *Plastics Technology*, December 1958, January 1959.
"A Visual Analysis of Flow and Mixing in Extruder Screws", B. H. Maddock, *SPE Journal*, May 1959.
"Basic Laws for Plastics Screw Extruder, Part I", G. Schenkel, *Kunststoffe*, January 1959.
"Basic Laws for Plastics Screw Extruder, Part II", G. Schenkel, *Kunststoffe*, February 1959.
"Basic Laws for Plastics Screw Extruder, Part III", G. Schenkel, *Kunststoffe*, March 1959.
"Processing of Thermoplastic Materials", Reinhold Publishing Corporation, January 1959.
"The Significant Flow Properties of Thermoplastics", Leonard B. Ryder, SPE ANTEC, January 1959.
"Some New Verifications of Power and Heat Theory in PVC Extrusion", F. C. Schutz, *SPE Journal*, April 1959.

BIBLIOGRAPHY—Extruder Design and Application

"New Machine With Screw Preplasticizer", *Modern Plastics 29*, 115, December 1951.
"Extrusion Dies and Take-Off Equipment", Kenneth O. Robbins, *Modern Plastics*, December 1955.
"Stock Thermocouple Pressure Gage and Rupture Disks for Use on Plastic Extruders", E. C. Bernhardt, *SPE Journal*, June 1955.
"Preheating Polyethylene and Impact Polystyrene Prior to Extrusion", Peter Wilton and Franklin D. Marrow, *Plastics Tech.*, March 1956.
"Extrusion Dies For Plastic Pipe", R. S. Perkins, *SPE Journal*, August 1956.
"Problems and Trends in European Extruder Design", E. Gaspar, *SPE Journal*, August 1956.
"General Purpose Extrusion Molding Machine", *Brit. Plastics 29*, 442, 1956.
"The Effect of Blow-Up Ratio on Blown Polyethylene Film Properties", Charles J. Kucher, *SPE Journal*, January 1957.
"Valved Extrusion", E. C. Bernhardt, SPE ANTEC, January 1957.
"Shape Extrusion Studies of "Zytel" Nylon Resin", Karl G. Tool, *SPE Journal*, January 1957.
"Nylon 6 Extrusion", Robert L. Hughes, *SPE Journal*, January 1957.
"Obtaining Maximum Surge-Free Production Rates With Acrylonitrile Copolymer Blends", E. J. Trunk, *SPE Journal*, February 1957.
"Advantages of Dual Thermocouples in Injection Cylinders and Extrusion Barrels", Richard K. West, *SPE Journal*, April 1957.
"Heating Systems for Extrusion Cylinders", W. H. Willert, *SPE Journal*, June 1957.
"Automated Sheet Extrusion", Frank R. Nissel, *Modern Plastics*, December 1957.
"Effect of Extrusion Conditions on Strength and Appearance of Polyethylene Pipe", J. F. Morris, *SPE Journal*, January 1958.
"Rigid Polyethylene Pipe", L. B. Croley and Robert Doyle, *SPE Journal*, January 1958.
"Polyethylene Monofilaments", J. F. Groel and J. H. Versteeg, *SPE Journal*, January 1958.
"Sheet Extrusion and Vacuum Thermo Forming of Higher Density Polyethylene", J. G. Farrow, *SPE Journal*, January 1958.
"Extrusion of Polyethylene Film with Controlled Properties", W. A. Haine and H. B. Robinson, Jr., *SPE Journal*, January 1958.
"Polyvinyl Chloride Dry Blend Extrusion in the Wire Coating Field", E. H. Hankey and R. D. Sackett, *SPE Journal*, January 1958.
"Advantages of Extended Barrel Extruders", L. D. Yokana, *SPE Journal*, January 1958.
"Nylon 6 Tubing-Extrusion Technique and Effects of Environmental and Processing Conditions on Strength", J. L. O'Toole, H. G. Tinger and T. R. von Toerne, *SPE Journal*, January 1958.
"Teflon 100X Perfluorocarbon Resin", A New Melt-Extrudable Fluorocarbon Resin, R. S. Mallouk and W. B. Thompson Jr., *SPE Journal*, January 1958.
"Extrusion and Thermoforming of Polyethylene Sheet", E. E. Griesser, A. L. Griff and H. F. Tomfohrde III, *SPE Journal*, January 1958.
"Induction Heating for Plastics Extruders", W. J. Goodwin, *SPE Journal*, February 1958.
"Dry Blend Extrusion", E. H. Hankey and R. D. Sackett, *SPE Journal*, March 1958.
"Use of Radiation Gages in Plastics Extrusion", G. I. Doering, *Plastics Technology*, April 1958.
"Role of Barrel Pressure in Polyethylene Film Extrusion", Dr. Walter S. Kaghan, *SPE Journal*, May 1958.
"Extrusion and Forming of High Density Polyethylene Blown Tubing", Robert Doyle, *Modern Plastics*, May 1958.
"The Ankerwerk Single Screw Injection Machine", *Plastics*, May 1958.
"Hannover 1958 Extruders", *Plastics*, June 1958.
"Barand 1½" Extruder", *Plastics*, June 1958.
"Extrusion of Clear Film From High Density Polyethylene", Robert Doyle, *SPE Journal*, June 1958.
"Extrusion Equipment of the World", *British Plastics*, July 1958.
"Plastics and Plastics Machinery at the German Industries Fair, Hannover 1958", Dr. J. Hausen, *Kunststoffe, 48*, p. 306-326, July 1958.
"The Engineering of Extrusion", E. O. A. Mange, *British Plastics*", July 1958.
"Extrusion—A Contemporary Assessment", A. Kennaway, *British Plastics*, July 1958.
"The Mapre Twin-Screw Extruder", *Plastics*, August 1958.
"Streamlining of Extrusion Dies", P. N. Richardson, *SPE Journal*, August 1958.
"The Ko-Kneader and Its Use in the Plastics Industry", *Plastics*, September 1958.
"What A Plastic Engineer Should Look for When Planning to Buy an Extrusion Machine", R. E. Monica, *Plastics Tech.*, September 1958.
"Nylon 6 Tubing Extrusion Techniques and Effect of Environment and Processing Conditions on Its Strength", J. L. O'Toole, H. G. Tinger and T. R. von Toerne, *SPE Journal*, October 1958.

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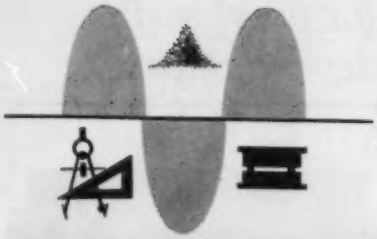


Edited by **Louis Paggi**, *Consultant*
E. I. du Pont de Nemours & Co., Inc.

FOR AUTHORITATIVE ANSWERS send your questions on molding to Louis Paggi, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Delaware.

MOLDING CYCLES

ANSWERS TO YOUR MOLDING PROBLEMS:

- *What bearing does mold surface have on ejectability?*
- *Can long pins of small diameter be cooled during molding?*

Q—We would like to produce a polyethylene container with a glossy finish. All else being equal, what bearing does the mold surface have on ejectability? Will a polished or a dull cavity surface provide greater release in the molding of polyethylene?

A—While cavity surface plays a major role in the ejection of some molded polyethylene items, other important factors should also be considered. Among the variables to be considered are:

Material Composition

Several polyethylene compositions are available for molding applications. Some of these compositions will produce moldings having a higher gloss without sacrificing ejection properties. All other conditions being equal, materials having a high melt viscosity (low melt index) and low volatile content will eject more readily.

Mold Cavity Surface

Highly polished cavity surfaces will usually aggravate the ejection problem as will very rough surfaces. The best surface is a very fine matte finish such as is produced by liquid or vapor honing with finely divided grit. If the dull or matte finish is produced by rubbing as with a stone or abrasive compounds, all of the strokes should be toward the parting line of the cavity.

Whatever the method used to produce the dull surface, it is very important that all of the indentations in the surface of the cavity wall be very narrow or small in diameter. The object here is to completely fill the mold cavity while the indentations in the cavity wall remain unfilled. When this condition is present, the contact area between the surface of the molded part and metal cavity will be reduced. The rough metal surface also will make it impossible to develop a high vacuum during ejection of a container-like part, thus facilitating ejection.

Molding Conditions

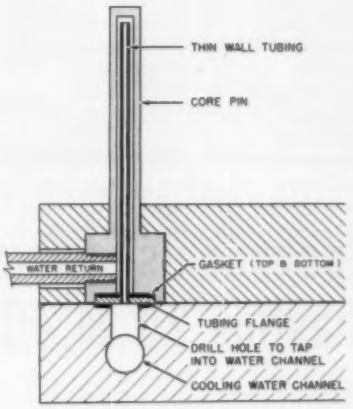
High material and mold temperatures, fast filling, low injection pressure, short ram-in time and short cycles all tend to improve surface gloss. Unfortunately these very conditions also tend to aggravate the ejection problem. The high material temperature makes the greatest contribution to the difficulty.

Mold Design

The ejection problem can be minimized or eliminated, when operating under conditions to produce glossy surfaces, if air ejection is incorporated in the design of molds used to produce deep draw items. Air ejection will often cause distortion or rupturing of the bottom of deep draw items unless the pressure and rate of flow of the air into each cavity is controlled within tolerable limits. In a multicavity mold, this can be accomplished by drawing the air from an accumulator manifold which in turn is filled through a pressure reducing valve.

Q—Is there anything that can be done to cool long pins of small diameter while molding? If not, have you found any way to design around them to enable molding on short cycles?

A—The most efficient method is to circulate water through the pins. Pins as small as 3/16" diameter have been successfully cooled by employing the design shown in the sketch.



WATER COOLED PIN

The most important feature of this design is the length of the thin wall tube. It should be held to an absolute minimum. The restriction to the flow of water resulting from the very small diameter tube is therefore minimized.

When contemplating this design, the following factors may be considered:

1. Thin wall tubing is available down to diameters so small (as little as 0.010" O.D.) as to be impractical to use.
2. Since the wall of the tubing is very thin, it should be made of a non-corrosive metal or alloy. Brass is satis-

(Continued on page 569)

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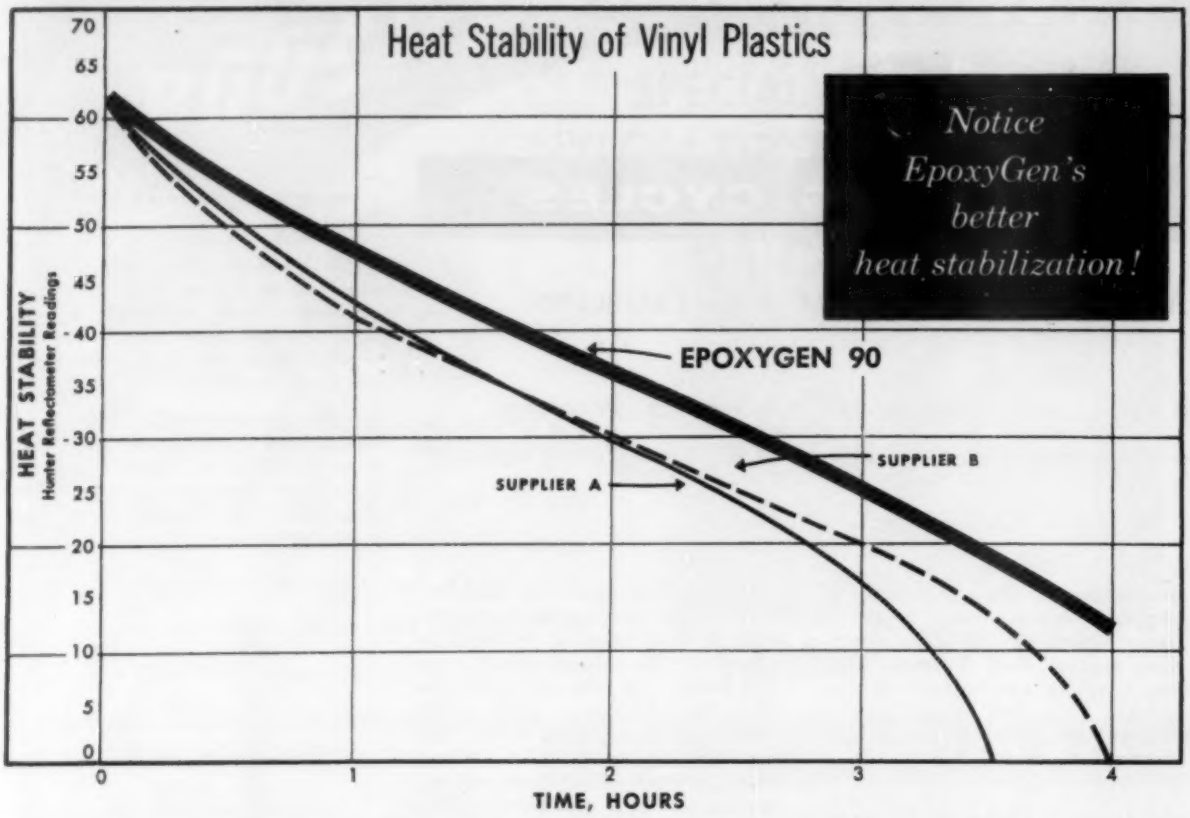

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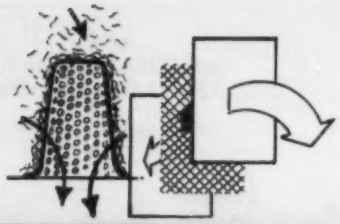

Edited by **George Lubin**
Grumman Aircraft Co.

REINFORCED PLASTICS

The Effective Use of High Temperature Resistant Polyester Resins

James P. Walton
Naugatuck Chemical Div.
United States Rubber Co.

THE DESIGNER and fabricator of new aircraft and missile devices are constantly confronted with the problem of finding satisfactory materials to perform well mechanically and electrically over wide temperature ranges. The development of new fabrication systems has fallen well behind the demand with the advent of jet and rocket propulsion. To aid in the development of structures requiring high temperature resistance and special electrical properties, chemical companies have intensified their efforts in heat resistant polymer research.

Plastic materials are playing an increasingly important role in the construction of vehicles designed for present day earth and space flight. Among the available plastic materials are reinforced high temperature resistant polyester resins. These resins, based mainly on a mixture of triallyl cyanurate and polyester alkyd, are now being employed in missiles and high speed aircraft where high temperature strength, radar transparency, low thermal conductivity and ease of fabrication are important factors.

Successful use in military applications has also prompted investigations in such uses as wire coatings, potting, chemical and heat resistant surfaces, foams, etc.

The introduction of thermally stable polyester resins, as opposed to the general purpose styrene-polyester, has created a vast number of new process variables for the fabricator. Only with proper control of these variables will the attainment of optimum properties be possible.

Progress

For several years Vibrin 135 manufactured by Naugatuck Chemical has been available to fabricators of high temperature resistant structures. More important applications have included missile nose cones, high temperature exposed radomes, and structural parts. Complete approval of this resin under USAF Mil. Specification R25042 has also been available.

The following limitations were evident to users of this material:

(a) Glass reinforced laminates were limited to 500°F exposures except for very short periods at 550°F to 600°F. Strength also falls off rapidly above 500°F.
(b) Exposures above 450°F required a fully crazed panel which was porous and prone to oxidative attack.
(c) The crazed panel required for higher temperature exposures sacrificed electrical properties, lowered initial hot strength and caused a more rapid loss in strength during high temperature exposure.
(d) Uncrazed panels exposed to temperatures above 450°F sometimes exhibited delamination between glass fabric plies.

With these limitations confronting the designer, an intensive research and development program was undertaken to eliminate these defects and bring out the innate high temperature properties of this resin.

Recently, a new material (Vibrin 136A) was introduced as a basic improvement in polyester heat resistant resin systems. It produces translucent, uniform, craze-free structures for long-term exposures at 500°F. Strength properties at elevated temperaures are improved 50-100%. Long term exposures at elevated temperatures provide 100% improvement in strength retention. It has already proven itself in more demanding heat resistant applications. It has been successfully used in applications where Vibrin 135 was previously found inadequate.

Curing Methods

One of the more important aspects of fabricating parts from heat resistant polyester resins is the proper cure procedure. The curing and postcuring of high temperature resistant polyesters can be compared to the alloying

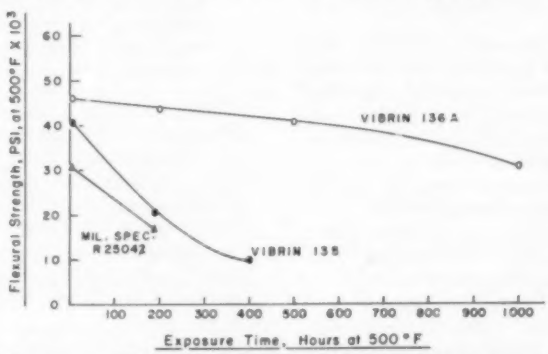

Figure 1. High-temperature resistant polyester resin glass-fabric laminates flexural strength after aging at 500°F.

TABLE I

Vibrin 136A Curing Requirements (60-70% Glass Reinforcement) (Bag Molding)

	Operational Temperature		
	460°F or less	460-500°F	over 500°F
Catalyst, %	0.2-0.4[a]	0.15-0.25[a]	1.0-2.0[b]
Primary cure temperature	230-250°F[c]	230-250°F[c]	180-200°F
Primary cure time, hours	1-4	2-4	¾-1½
Secondary cure temperature (oven)	—	—	380°F[d]
Secondary cure time, hours	—	—	2-3
Postcure cycle			
Appearance of panel	tan, translucent[e]	tan, translucent[f]	brown sl. craze[g]

Note:
(a) tertiary butyl perbenzoate.
(b) mixed 50/50 tert. butyl perbenzoate and Luperco CDB.
(c) press molded parts require 10-20°F lower temperature depending on heat transfer variation from oven to platens.
(d) parting film must be removed before 380°F exposure.
(e) one hour each at 350°F, 400°F, 430°F, plus 10 hours at 460°F.
(f) one hour each at 350°F, 400°F, 430°F, 460°F, 480°, plus 10 hours at 490°F.
(g) one hour each at 350°F, 400°F, 430°F, 460°F, 480°F, plus 6 hours at 500°F.

TABLE II

Vibrin 136A Laminate Properties 12 Ply 181-Garan, 38% Resin

(all tests conducted at the exposure temperature)

Property	
Flexural Strength, psi	
Room Temperature	65000
½ hour at 500°F	47000
192 hours at 500°F	40000
500 hours at 500°F	40000
1000 hours at 500°F	31000
½ hour at 550°F	33000
192 hours at 550°F	20500
Flexural Modulus, psi × 10⁶	
Room Temperature	3.5
½ hour at 500°F	2.7
192 hours at 500°F	2.3
½ hour at 550°F	2.5
Tensile Strength, psi	
Room Temperature	50000
½ hour at 500°F	40000
192 hours at 500°F	26000
Compression Strength, psi	
Room Temperature	45000
½ hour at 500°F	30000
200 hours at 500°F	20000

TABLE III

Electrical Properties Vibrin 136A Casting and Laminate

	Casting (0.6" Thick)	181 Garan Laminate (0.6" Thick)
Dielectric Constant		
1 megacycle, dry	3.6	4.09
wet	3.75	4.23
9375 megacycles, dry	2.85	4.05
wet	2.85	4.07
Loss Tangent		
1 megacycle, dry	0.035	0.012
wet	0.033	0.013
9375 megacycles, dry	0.012	0.008
wet	0.012	0.010

and heat treating of metals. The proper combinations of catalyst type, catalyst concentration, primary cure, postcure and cooling methods all contribute to the final properties of the laminate structure. It is well known in general purpose styrene-polyester systems that creep and fatigue characteristics change quite significantly with varying cure procedures. High-temperature resistant systems are more complex since they depend on a free radical peroxide cure at median temperatures plus a thermal free-radical cure at elevated temperatures. The former is referred to as primary and secondary cure and the latter as the postcure. The following is a list of the more important variables to be considered.

1. Catalyst type—Organic peroxides (usually long half-life catalysts alone or combined with short-life systems), organo-metallics are under investigation.
2. Catalyst amount—Varies with end use requirements.
3. Primary cure temp.—Varies inversely with catalyst concentration from 180°F to 260°F.
4. Primary cure time—Usually long enough to provide some hardness, minimum Barcol hardness approximately 40.
5. Postcure temperature—Varies with end use requirement.
6. Postcure time—Varies with end use requirement.

Present laminating methods consist mainly of vacuum bag, pressure bag, and matched die molding systems. Cure procedures are based on end use operating temperatures and may be grouped as follows.

1. Exposures requiring less than 460°F.
2. Exposures requiring greater than 460°F but less than 500°F.
3. Exposures requiring greater than 500°F. Other considerations which may vary the cure requirements over these ranges are the heatup rate of the part to operating temperature, cycling effects, and type and amount of reinforcement.

Table I gives the general requirements of catalyst concentrations, primary cure and postcure temperatures for a bag molded glass fabric laminate containing 60 to 70% glass by weight. For press curing, steam and electrically heated platens should employ the lower temperatures listed.

Properties

Properties of typical laminates prepared from Vibrin 136A are listed in Table II, Fig. 1 and Fig. 2. Laminates were prepared according to the schedule in Table I.

Electrical Properties are listed in Table III and Fig. 3. The relatively low and almost constant value for dielectric constant and loss tangent with increasing temperatures up to 500°F appears to be unique in these polyester systems.

Other Applications

Present and potential uses for high-temperature resistant polyesters are not limited to glass-

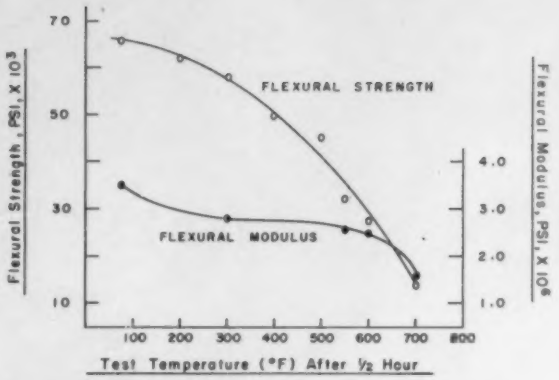
FLEXURAL STRENGTH
FLEXURAL MODULUS
Flexural Strength, PSI, X 10³
Flexural Modulus, PSI, X 10⁶
Test Temperature (°F) After ½ Hour

Figure 2. Vibrin 136A glass fabric laminate flexural strength and modulus vs. temperature.

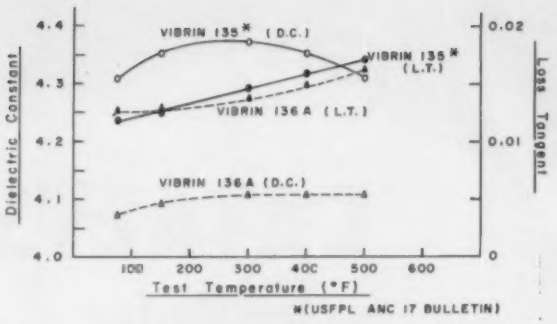

Figure 3. High-temperature resistant polyester resin glass-fabric laminates electrical properties vs. temperature.

reinforced structural parts. Potting of electronic parts has been an important application for several years. These systems make use of excellent ease of handling, absence of reaction products and the ability to completely polymerize without pressure. New mechanical means of foaming polyesters should provide heat resistant rigid foams. The need for heat resistant wire coatings has prompted evaluation of Vibrin 136A for magnet wire and insulated cable coatings. Initial results have been very promising.

Potting and sealing applications have proven particularly successful.The slight change in dielectric properties from 77°F to 500°F provides an excellent material for high-temperature resistant electrical applications.

In most applications, excepting thin coatings, an inert filler is employed to reduce shrinkage and prevent stress formation. Calcium carbonates and pulverized sand have been found particularly useful. In most cases fillers are chosen to provide minimum loss of desired electrical properties.

Curing methods will vary widely for each application but can be summarized as follows:

Coatings—Resin containing 1-2% benzoyl peroxide may be applied thinned with ketone solvents. Bake at 400-500°F for 1-2 hours.

Potting—Using 1.0% benzoyl peroxide cure at 180°F for one hour and postcure by slowly raising to desired operating temperature, holding at the operating temperature for several hours. Larger masses require slow increment heat increases with approximately one hour at each level.

Foams—Room temperature primary cure can be accomplished by employing 1-2% benzoyl peroxide and 0.2-0.6% of Naugatuck Chemical's Promoter #3. Gelation and cure can be timed to occur at the peak of foaming. Standard postcures may then be employed.

Hand Layup—Laminating with reinforcing fibers at room temperature also makes use of the 1-2% benzoyl peroxide and 0.2-0.6% Promoter #3. Laminates may make use of a surface layup of Vibrin 135 or 136A backed by a standard general purpose laminate based on the lower cost styrene type resins. The surface containing the Vibrin 135 or Vibrin 136A will provide maximum chemical-, abrasion-, and heat-resistance.

Ω

ANSWERS TO YOUR MOLDING PROBLEMS:

(Continued from page 565)

factory for most applications.

3. When very small tubing is used, the cooling water should preferably be re-circulated through a cooling device, filtered through very fine mesh screen and should contain an anti-rust agent such as a small quantity of soluble oil.
4. If drilling of the core pin presents a problem, heavy wall carbon steel tubing plugged at the top and suitably attached to the base may be considered as a substitute.
5. Since the specific heat of water is approximately 10 times that of steel, the volume of water required for cooling is not very great. Therefore, the clearance between the I.D. of the core pin and the thin wall tubing need not be greater than just necessary to maintain circulation.
6. The metal used for the core pins should have a relatively high thermal conductivity. The thermal conductivity of stainless steel for example, is only approximately ¼ that of carbon steel.
7. The rigidity of a core pin is not greatly affected by reasonable coring. For example: A tube having an I.D. equal to 50% of the O.D. has a rigidity equal to approximately 93% of a rod of the same diameter. When the I.D. is equal to 75% of the O.D. the rigidity is equal to approximately 68% of a solid rod of the same diameter. A tube having an I.D. of 3/32" and an O.D. of 3/16" would therefore be almost as rigid as a 3/16" diameter pin of the same material.

Ω

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Rahway, N. J.

Edited by **Thomas A. Bissell**
SPE Executive Secretary

NATIONAL ACTION

SPE Raises Its Voice To Industry

Frederick C. Sutro, Jr.,
SPE National President

AS STATED in our Constitution, SPE's objective is to promote and disseminate scientific and technical information relating to plastics.

This purpose is being accomplished primarily through publications, meetings, committee activities and their reports, and informal conferences.

Incidentally, all of these methods combine to form the Public Relations program of SPE. For example, every *good* SPE publication, or SPE Meeting, makes new friends and influences people favorably toward our Society. As a National Society, we have Public Relations responsibilities to our members, to the plastics industry, and to all other industries that use plastics today or could use plastics tomorrow.

A study of our recent progress has revealed to your Executive Committee and National Council that our Public Relations program should be expanded and accelerated. As a result, the SPE Public Relations Committee, working under the Chairmanship of Lucien R. Greif, has recommended a program designed to meet our current and future needs. At the National Council Meeting held in Denver on June 12, this program was accepted in principle, and funds were included in the 1959-1960 budget to enable Tom Bissell to expand this activity.

Although the program will depend primarily on publicity releases, every known means of communication will be employed if and when they are indicated—TV, radio, telephone, telegraph, newsletters, magazine articles and editorials, brochures, personal letters, public speakers, and personal contact.

As the use of plastics increases in some industries and spreads to new industries, the need to tell all industry what you SPE members are doing and plan to do, becomes increasingly important.

Establishment of a stronger Public Relations program and its implementation was set forth as one of our 1959 goals. The support of the National Council in giving unanimous approval to a more active Public Relations program is most gratifying.

Membership Passes Another Milestone

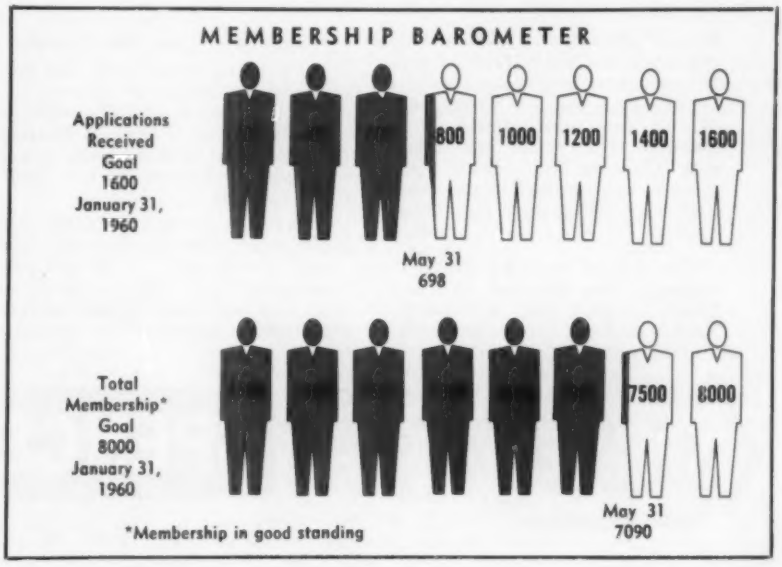
SPE members in good standing passed the 7,000 mark in May, as indicated by the barometer below. Congratulations are in order for this achievement to our Section Membership Chairmen and their Committees; to our National Membership Committee, to our National Membership Administrator, and to our New Sections Development Committee.

At his June 12 National Membership Committee meeting in Denver, Chairman James R. Lampman emphasized that accelerated activity along three separate lines is necessary to reach President Sutro's goal of 8,000 members for January 31, 1960:

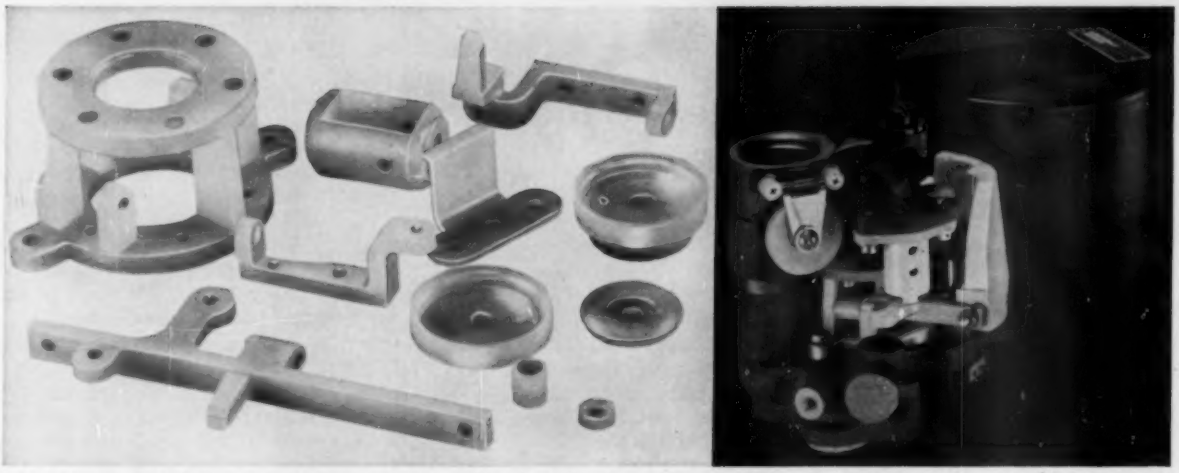
1. Promotion of new adult members.
2. Promotion of new student members and student branches.
3. Reclaiming members delinquent in their dues.

Mr. Lampman pointed out that the only purpose of his new Regional organization is to assist the Section membership workers on the firing line.

Most of this Committee meeting was devoted to a "brainstorming session" which resulted in a long list of successful means employed by various Sections and other technical societies to promote membership. These ideas will be incorporated in a "Guideposts for Section Membership Chairmen" being developed by the Committee to assist these key workers to do more effective jobs.



New ideas in **NYLON**



14 parts made of Spencer Nylon, all inter-related and inter-working, go into this new valve developed by Aero Supply Mfg. Co. The parts are molded to exact tolerance by Plastic Molded Parts, Inc.

Spencer Nylon Chosen For Exact-Tolerance Valve Assembly

How Spencer Nylon 600 met the rigid requirements of Plastic Molded Parts, Inc., in molding a new aircraft valve assembly for Aero Supply Manufacturing Co.:

A new aircraft fuel system valve assembly, created by Aero Supply Manufacturing Company of Corry, Pa., has 14 nylon parts, plus a few metal parts. Tolerances on all 14 of the inter-related and inter-working nylon parts must be maintained to the degree that they make up a functioning unit!

The job of molding the nylon elements was assigned to Plastic Molded Parts, Inc., of East McKeesport, Pa.

Spencer Nylon The Answer

To mold parts with the exact tolerances needed in this application required a material with low shrink value. Plastic Molded Parts tested two different brands of nylon and chose Spencer Nylon for the job.

Because component parts made of Spencer Nylon are metal-strong and plastic light, more and more designers and manufacturers are looking to this wonder-material to solve problems of weight—without sacrificing strength or durability.

Special Properties Solve Problems

Besides strength and lightness, Spencer Nylon offers the advantages of extreme abrasion resistance and low friction properties, plus an additional, unique feature: Spencer Nylon is self-lubricating!

If you are faced with a product problem, why not investigate the special properties of Spencer Nylon. You, too, may discover that Spencer Nylon can supply the answer you have been seeking.

For more information on Spencer Nylon, write direct to Spencer Chemical Company, Dwight Bldg., Kansas City 5, Mo.

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TECHNICAL MEETINGS CALENDAR

16TH ANTEC

ANNUAL TECHNICAL CONFERENCE—January 12-15, 1960, The Conrad Hilton, Chicago, Ill. Sponsored by the Chicago Section. For more information, contact General Chairman Franklin L. Fine, Rohm & Haas Co., 5750 W. Jarvis Ave., Chicago 31, Ill. Request for papers on page 275 of the April SPE Journal.

1959 NATEC

NATIONAL TECHNICAL CONFERENCE—October 13-14, 1959. The Ambassador, Los Angeles, Calif. For more information, contact General Chairman, Jack G. Fuller, c/o Chemtrol Co. 10872 Stanford Ave., Lynwood, Calif. See tentative program on page 273 of the April SPE Journal.

RETECS

VINYLS—October 7, 1959, Cleveland Engineering Society, 3100 Chester Ave., Cleveland, Ohio. All day conferences beginning at 9 a.m., will cover many phases of vinyls. Speakers and subjects will be announced. Further information contact Jack R. Pecktal, 13212 Shaker Square, Cleveland 20, Ohio.

PLASTICS FINISHING—October 16, 1959, The Niagara Hotel, Niagara Falls, N. Y. Sponsored by the Buffalo Section in cooperation with the Plastics Finishing PAG. For information write to Chairman Gordon K. Storin, 3 Forest Rd., Lewiston Heights, Lewiston, N. Y.

PLASTICS IN THE SHOE INDUSTRY—November 4, 1959, Statler Hotel, St. Louis, Mo. Sponsored by the St. Louis Section. For more information write to Otto Wulfert, Chairman, c/o Wagner Electric Co., 6400 Plymouth Ave., St. Louis 14, Mo.

PLASTICS IN PACKAGING—November 19, 1959, San Francisco, Calif. Sponsored by the Golden Gate Section. For information write to Chairman Frank D. Allen, L. H. Butcher Co., 15th & Vermont Sts., San Francisco 1, Calif.

STABILITY OF PLASTICS—December 1959, Washington, D. C. Sponsored by the Baltimore-Washington Section. For information write to Chairman Myron G. DeFries, Atlantic Research Corp., Alexandria, Va.

SECTION MEETINGS

TOLEDO—August 1, 1959. Annual outing will be a Reef Fishing Trip.

QUEBEC—September 18, 1959. Golf Outing to be held at Granby, P.Q.

GOLDEN GATE—September 24, 1959. Tour of the Reichhold Chemical plant. Dinner location to be announced.

CENTRAL INDIANA—September 29, 1959. Ladies Night and a color film, "House of the Future." Talk to be given by T. J. Martin, Monsanto Chemical Co.

Standards for Reporting Properties Urges Member Support

Active support of the Professional Activities Group #14 who have organized to assemble test methods and draft a standard form for reporting properties of plastic materials, is earnestly being sought. Only by member participation can the success of this committee be ensured.

Present confusion in this area is well known, and it is the intention of the committee to strongly suggest to manufacturers that this form be universally followed.

A petition signed by twenty-two members requesting organization of this group was approved by National Council in September 1958. Yet, due to disappointing lack of member attendance, an organizational meeting scheduled for April 15th in Washington, was cancelled.

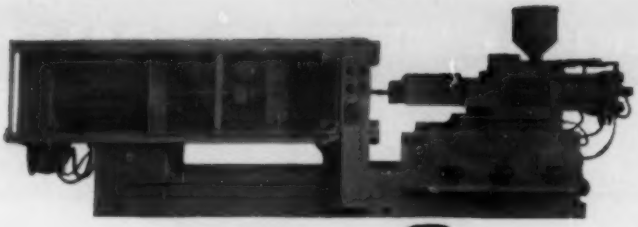
As an SPE member, you are requested to join and actively support this committee. The successful fulfillment of the scope of the group will be of tremendous benefit to SPE and the plastics industry.

Your individual assistance is needed now, without it the establishment of the committees plans cannot succeed. Lend your support and disclose your interest by writing to: Louis B. Allen, Chairman, Steering Committee, IBM Committee, North St., Endicott, N.Y.

Progress of the First NATEC

Theme of the first NATEC, to be held October 13-14, Ambassador Hotel, Los Angeles, Calif., and sponsored by the Southern California Section, will be "Plastics Engineering—The State of the Art Today." First advance registration mailing will be made to the entire membership before July 15, and copy for the advance program, advance registration card and letter of transmittal, by August 10. Luncheons are included in the registration fee. The September issue of SPE Journal will contain technical and luncheon programs and digests of each paper.

The executive committee will consist of: Jack G. Fuller, General Chairman; Raymond Seymour, Vice Chairman; Howard Malby, Arrangements; Samuel Olaesky, Program; Harold Kotkin, Secretary; Robert Steinman, Treasurer; Walter Kadlec, Registration; Paul Metzger, House; Louis Tallman, Speakers; Fred Rea, Publicity; Robert Lindegren, Ticket Sales; Samuel Silberkraus, Information Desk; William Brooks, Catering; Milton Buck, Visual Aids; Thomas Schaub, Printing; Charles Zimmerman, New Member Desk; Roderick Maybee, Sgt.-At-Arms.



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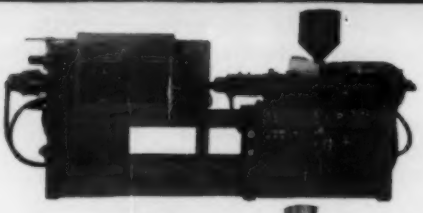

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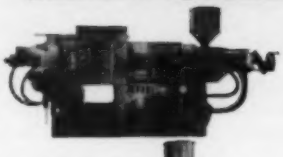
16-20 Ounces

HA 12-300
12-16 Ounces

HA 8-275
8-10 Ounces



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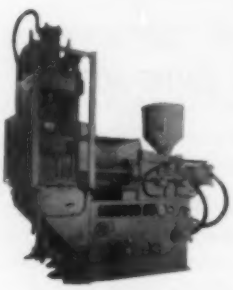
4-6 Ounces

HA 2-125
2-3 Ounces



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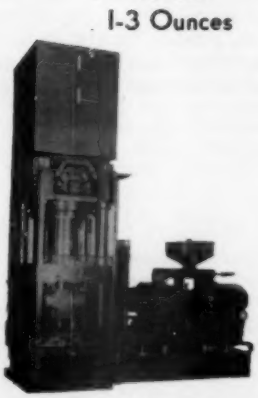

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U.S.I. POLYETHYLENE NEWS

A series for plastics and packaging executives by the makers of PETROTHENE polyethylene resins

Packaging Notes

New research study on packaging has been issued by the American Management Association in book form. The book offers a comprehensive inventory of literature on packaging research. Current trends in packaging research, materials and methods are described. The book also lists principal sources of packaging information, such as periodicals, directories and manuals. The study includes a survey of packaging research needs and the special requirements of particular industry groups. The book is available for $6.00 from the AMA., 1515 Broadway, New York 36, N. Y.

Polyethylene bags for heavy transformers are saving an electrical equipment manufacturer $33,000 annually in packaging material costs. The company is shipping transformers ranging in weight from 300 to 1800 pounds in gusseted, 4-mil polyethylene tubing bags.

The transformers are readied for shipment by mounting them on prefabricated wooden skids, placing pieces of single-wall corrugated over the tops to protect the finish. The polyethylene bags are then placed over the transformers.

Previously, the company shipped its transformers in heavy paper covers and wooden crates. The new bags have resulted in substantial savings in labor costs and shipping weight. Hidden damage during shipment has also been reduced.

New machine does four color printing on plastic bottles. The machine accommodates one to four colors, does its printing by offset. The machine operates without mandrels, uses compressed air to print the plastic bottles. The unit employs two large conveyors and twin chains holding 14 bottles on slides.

Expanding carton with polyethylene liner is being tested by the Army as a means of serving hot rations to troops in the field. The carton, which holds dehydrated rations, has uncut, pleated top flaps which increase the carton's volume by a third when open. A polyethylene liner is unfolded and placed in the carton, hot water is poured into the liner and the dehydrated rations are placed in the liner and reconstituted. The increased size of the opened carton easily holds the extra volume of the reconstituted rations. The liner and carton form a leakproof mixing and serving container.

The new carton is expected to have civilian retail applications for powdered food products requiring the addition of liquid. These might include such mix-and-serve products as fruit drinks, milk, cocoa, gelatin desserts, pudding, hot cereals and instant coffee.

U.S.I. Offers New Literature For Polyethylene Processors, Packagers

Data on Film, Pipe, Molded Housewares, New Commercial Standards

Valuable information on polyethylene processing and packaging is now available from U.S.I. in the form of free booklets, processing tips and reference data. The information is based upon U.S.I.'s extensive polyethylene research conducted at the company's Polymer Research Laboratory in Tuscola, Ill. and from industry-wide marketing and packaging studies.

Among the literature offered is:

PETROTHENE ***Polyethylene — A Processing Guide*** — A 96-page booklet discussing

technique for processing polyethylene, processing problems, and polyethylene properties.

Formulas and Tables for Polyethylene Film and Bags for determining such factors as feet of film of various gauges from a given quantity of resin; weight per 1,000 feet of film, or number of bags of a given size that can be made from a quantity of polyethylene film. The tables are particularly useful to film extruders and those who make or use polyethylene film bags.

Slide rules with the same type information are also available.

Which Polyethylene Film Should I Use, which relates to the new Recommended Commercial Standard for Polyethylene Film (TS-5438) and indexes the various types and gauges of polyethylene film recommended for different packaging jobs. The corresponding PETROTHENE resins for each type film are also listed for easy reference by extruders.

Other literature offered includes a booklet on polyethylene pipe standards, "How to Choose and Use Polyethylene Plastic Pipe," "The Goose That Laid The Golden Egg," U.S.I.'s famous guide for buying polyethylene housewares; a complete collection of the well-known "Processing Tips" which U.S.I. has published regularly in leading plastics publications; and the booklet "Polyethylene Creates New Opportunities in Packaging."

To order any of this material, write to Editor, U.S.I. Polyethylene News, U. S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

Poly-Coated Pipe Resists Underground Corrosion

The first steel pipe in the industry to be coated with an extruded plastic is finding widespread use by gas, oil and chemical companies with underground pipeline installations.

The pipe is factory coated with extruded polyethylene applied over an elastic adhesive undercoating. The coating has high insulation resistance and dielectric strength. This is especially important in underground pipelines where stray ground currents are a troublesome cause of pipe corrosion. The plastic coating is so tough and resilient that rocks can be bounced off the pipe without piercing the coating. The pipe can be bent in the field without damage to the coating.

Polyethylene Film "Bubble" Speeds Construction Work

A "warm air bubble" of polyethylene film inflated over excavation site thaws the area sufficiently for concrete to be poured even in subfreezing winter weather.

This novel application of polyethylene film has been used successfully by several construction companies. In one operation a 50 x 64 foot sheet of film was anchored to the ground with cement building blocks and inflated with warm air from the blower of a temporary furnace. About two pounds per square inch pressure was used. Concrete was then poured in temperatures that ranged down to zero. The bubble was left up for three days to give the concrete time to cure without freezing.

New U.S.I. Plant Reaches Full Output In 6 Weeks

U.S.I.'s new 75 million pound polyethylene plant at Houston, Texas, reached capacity production just six weeks after going on stream.

Production reports show that quality of the material produced is high. A sizeable proportion of the output to date has been film grade and coating resins. Plans are already underway to double the capacity of the Houston plant by the third quarter of 1960.

U.S.I.

Vol. IV, No. 4

POLYETHYLENE PROCESSING TIPS

HOW TO ACHIEVE SATISFACTORY PIGMENT DISPERSION IN DRY COLORING

Dry coloring thermoplastic resins with pigments is a firmly established method for producing colored plastic articles. It has the inherent advantages of low cost, minimum quantity of uncommitted resin inventory, minimum losses due to obsolete colored polyethylene, and faster customer service on special orders.

For these reasons, polyethylene molders and extruders have made dry coloring the choice for all but the most exacting color applications.

Satisfactory pigment dispersion is the key to turning out a quality product by dry coloring. Factors affecting how well the pigment is dispersed in the resin include processing conditions, pigment characteristics, and resin properties.

Processing Conditions

Adequate tumbling is necessary for intimate mixing and uniform distribution of pigments all around the polyethylene pellets. For conventional drum tumblers, operating rates of 30-40 rpm and tumbling times of 15-30 minutes are recommended. If wetting agents are used, clear polyethylene should first be tumbled with them alone. Then the pigment should be sifted onto the pellets and the tumbling repeated.

Additives should be used with caution lest they adversely affect dispersion or resin properties. Wetting agents or lubricants, if used, must be compatible with polyethylene. The quantity added should be held to a minimum (about 0.2 lb per 100 lb of resin) to reduce the possibility of pigment agglomeration, additive exudation, or both. Too much low-molecular-weight polyethylene, which improves dispersion, must be avoided or physical properties of the resin, such as stress crack resistance, may be impaired.

Pinpoint gating and small-diameter nozzles improve dispersion and, wherever possible, should be incorporated in the mold design. Such mechanical aids as dispersion plugs or breaker plates will improve dispersion. Often, however, these mean a sacrifice in production rates.

Absolute cleanliness of hopper, tumblers, and other equipment is a must. This is particularly important where several colors are to be processed.

Pigment Characteristics

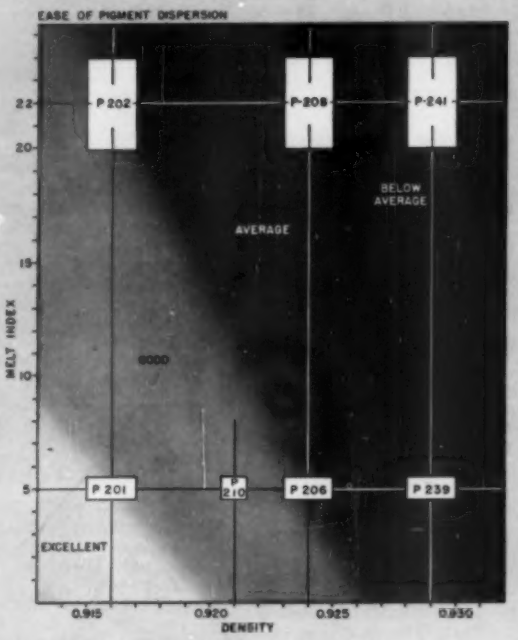
To be sure of results, stringent quality specifications for pigments are a necessity. Pigments must be of high quality, finely ground, and readily dispersible. They must also be stable to heat and light, not change color in the molding process, and not migrate or bleed in the molded piece. The amount of color added is dependent upon the type of pigment but normally will be in the range of 0.1 to 1.0 lb per 100 lb of clear polyethylene.

Resin Particle Size and Density

Superior dispersions are obtained with polyethylene of uniform pellet size, without "longs" or excessive fines. Cubes ⅛ in. in size, or smaller, are recommended for maximum color uniformity, because the smaller the pellet, the more uniform will be the color.

The density of the resin affects the ease with which pigments can be dispersed. Tests at the U.S.I. Polymer Service Laboratory show that for PETROTHENE® resins in the 0.914-to-0.929-density range, ease of pigment dispersion decreases as the density increases.

Dispersibility ratings for seven PETROTHENE resins within this range, and having melt indexes of 22 and 5, are charted on the accompanying graph. In all cases, an organic pigment difficult to disperse was tumbled with the resin, and the resultant compound molded in a conventional molding press. No mechanical dispersion aids in the nozzle or chemical dispersion aids such as mineral oil were used. Molding



conditions were kept as uniform as possible. Ratings were based on visual examination of the moldings under a strong light. As the graph shows, all other conditions being constant, a lower-density resin makes good color dispersion easier to attain. But it should be remembered that different results may be obtained by using dispersion aids, modifying mold design, or otherwise altering processing conditions.

U.S.I. technical service engineers can recommend the best PETROTHENE resins, coloring formulations, and processing conditions for various applications. They will be glad to work with you on any current production problem or future dry-coloring applications you may have.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
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SECTION NEWS

Ontario

The Case for Linear Polyethylene

Harold A. Shure

Attended by 62 persons, the May meeting had as guest speaker, E. J. Moreau, DuPont of Canada Ltd. His topic "The Case for Linear Polyethylene Water Pipe," disclosed that one big market for linear polyethylene is in the pipe industry. Advantages of this material over steel are, flexibility, low friction, light weight, and impermeability to water. Applications: cattle watering systems, irrigation, municipal water installations, artificial rinks and industrial uses.

Two failures in the performance of linear polyethylene pipe must be watched for. These are a ductile type of burst, where excessive internal pressures are used; and brittleness at low level temperatures which eventually will develop slits in the pipe.

The linear polyethylene pipe is affected by environmental stress cracking when subjected to adverse type fluids.

Normally however, linear polyethylene pipe using a safety factor of 1.3 and a hoop stress of 711 P51 at a temperature of 68°F should have a life of 50 years.

In making a comparison between low density and high density materials, basing the working pressure on 100 psi, the following results are obtained.

	Wall thick	Wt./Ft.
	1" dia. pipe	
L. Density	0.188	0.290 lbs.
H. Density	0.088	0.128 lbs.
	2" dia. pipe	
L. Density	0.369	1.125 lbs.
H. Density	0.172	0.496 lbs.

A new market will be open in the future in municipal installations which now use such materials as, cast iron, cement asbestos, reinforced concrete, steel, copper, galvanized iron, and lead.

From the following comparison on cost per foot, it can be easily sen that linear polyethylene competes with the other metallic materials.

	½"	2"
Copper	.20¢	$1.21
Galvanized iron		.60
Linear Poly	.04	.37

In concluding, we find that linear polyethylene has many definite advantages and the future looks promising, but there is still much developing to be done on couplings and pipe specifications.

Pittsburgh

First RETEC is Held

John E. Parks

The luncheon speaker, J. H. DuBois, consulting engineer and SPE Past President, addressed 167 guests, nearly one-half of the attendance being from the steel and fabricating industries.

In his talk, Mr. DuBois brought out the "advances and things-to-come in the replacement of and joining of plastics in the metal industries." He emphasized factual cases of plastics completely replacing steel; plastics in combination with steel; and the future of plastics in these two realms. The statistics he presented relative to the growth of plastics in the metal industries were quite alarming to the representatives from the steel industries, for they were unaware of this tremendous growth in the past two years.

Mr. DuBois also brought to light the tremendous amount of research and development of new materials which are coming on the market every day to stimulate the replacement of harder materials.

The Pittsburgh Section RETEC was honored with the presence of the National President Frederick C. Sutro, Jr., and Thomas A. Bissell, Executive Secretary.

Invocation was presented by the Rt. Rev. D. A. Lawless. The welcoming address was given by City Councilman Bennett Rogers, who spoke in the absence of Honorable Mayor Gallagher.

The RETEC proved, by reaching out into a field completely divorced from plastics, that there are other industries not only concerned with, but joining the trend in the part plastics is taking in replacing other materials.

Rochester

Spring Cruise

John T. Bent

On May 23 the "Spring Cruise" was held at the Rochester Yacht Club for 175 members, their fami-

Pittsburgh Section of SPE Holds First RETEC on May 7
"Plastics in the Metal Industries," was the theme of the first RETEC held at the Penn-Sheraton Hotel, Pittsburgh, Pa. Pictured are, left to right: RETEC Chairman John E. Parks, The Hydraulic Press Mfg. Co.; Luncheon Speaker J. H. BuBois, consulting engineer; Frederick C. Sutro, Jr.-SPE National President; and Thomas A. Bissell, Executive Secretary.

lies and friends. Richard Cleaver was General Chairman of this annual event. Mrs. Lew Hamel and her committee were in charge of refreshments. Directors of this Section expressed gratitude for generous gifts given by many companies and individuals.

Western New England

Social Activities End Season

Armand G. Winfield

A dinner-dance and golf outing ended the pre-summer season, held at the Farmington Country Club. Over 80 persons attended this affair, including wives and friends.

Richard J. Plichta, Fuller Brush Co., retiring President was presented with a desk barometer. Other retiring officers were: Alvino Aliberti, A & M Tool & Die Co., Vice President; Wesley S. Larson, DeBell & Richardson, Inc., Secretary; and Lawrence W. Freeman, Plax, Treasurer.

George W. Martin, Holyoke Plastics, Vice President of National SPE, and a W.N.E. Past President introduced and installed the new officers and directors for the 1959-1960 season.

President: Wesley S. Larson, DeBell & Richardson, Inc.; Vice President: Edward Duda, Holyoke Plastics; Secretary: Blakely McNeill, Fuller Brush Co.; Treasurer; Water E. Klesper, Holyoke Wire & Cable Co.

Directors (3 year terms): Paul H. Crane, Jr., Rohm & Haas Co.; Robert Pollard, Monsanto Chemical Co.; Armand G. Winfield, DeBell & Richardson, Inc.

Paul H. Crane, Jr. was chairman of the dinner-dance and golf outing and Wilbur N. Oldham, American Cyanamid Co., was winner of the Low Gross Golf prize.

Kansas City

Adhesives for Plastics

Donald C. Crawford

On March 17th the meeting was held at the Twin Oaks Restaurant, with 19 persons attending. President Robert Thomson called the meeting to order, and encouraged the sending of the ballot cards to the National Office. Norman Worrell of the Kansas City Art Institute was introduced as was Hank Glasgow of 3M Corporation. The speaker, John Middleton, 3M Corporation was then introduced.

Mr. Middleton spoke on adhesives for plastics. He discussed methods of designing for adhesive bonding and the types of stresses to which adhesives are normally subjected. He suggested the selection of an adhesive based on the performance required, and discussed the methods of bonding and the nature of adherence. He then went into several case histories of adhesive evaluation.

The meeting was adjourned at 9:30 P.M.

Eastern New England

National Steering Committee of VIPPAG Among Guests

H. C. Cookingham

George Kovach, President, presided at the May meeting which was held at Armand's Beacon Terrace in Framingham, Mass. Members and guests numbered 113.

George Dougherty, Vice Chairman of the Program Committee, introduced the guests and speakers for the evening. Among the guests introduced were the following members of the National Steering Committee of VIPPAG: Al Whitney, Roy Kern, Saul Bobstein, and Irving Podell. Speakers for the evening were as follows:

Melvin M. Gerson, Sandoz, Inc., discussed organic pigments and how a proper understanding of their reactivity and stability permits the plastic formulator to meet the requirements for color tolerances and durability required by end users.

Robert Zabel, E. I. duPont de Nemours Co.. Inc., discussed the use of inorganic pigments with organic pigments and how the proper selection of inorganic pigments enables the plastic processor to extend color range, reduce cost, and obtain better pigmented plastics.

Richard Williams, Godfrey L. Cabot, Inc., spoke on the technique of dispersion, methods of measuring the degree of dispersion, and the properties of various dispersions as related to end use applications of carbon black.

North Texas

Name Officers and Committee Chairman

David A. Daniels

T. T. Tucker, Jr., head of Tommy Tucker Plastics, Dallas, and presently Vice President of the Section, will assume duties of President on October 1st. Other officers scheduled to assume positions within the next 6 months are: David A. Daniels, Vice President; Ernie Dourlet, Secretary and Dominic Novelli, Treasurer. At the Board of Directors meeting on June 3, Hubert Poskey resigned as a Director and Treasurer and Dominic Novelli will assume the job as Treasurer. The Board of Directors then elected William McConnell to fill the unexpired term of Director. Committee Chairmen who are slated to take over are William McConnell, Program Chairman; Robert Myers, Membership Chairman; Joseph Kern, Publicity Chairman; James Stuart, Finance Chairman. Raymond Perkins, has been nominated as Chairman of the RETEC for next year.

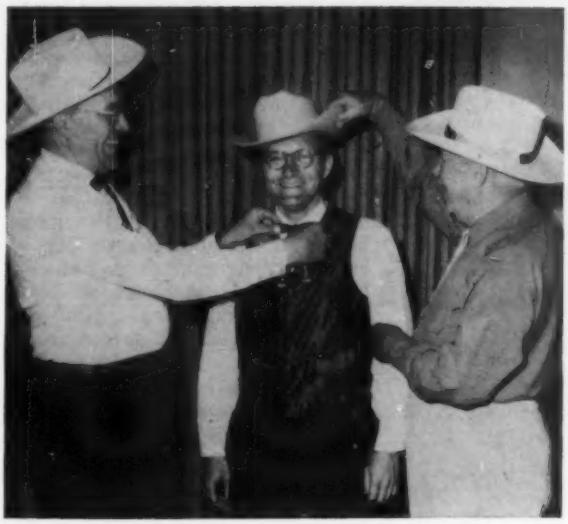
Milwaukee

Polyolefins Film Presented

James C. Engman

Joseph Stewart substituted for President Herbert Goeden. The fifty members and guests present accepted the financial report and program to enroll new members and increase the present one-hundred-and-ten member roll.

William Murray introduced John McKeen, Hercules Powder Co., and the technical portion of the meeting opened with a film presentation of Hi-Fax and Pro-Fax polymers. A question and answer period followed as well as an opportunity to browse through a display of plastics technical literature prepared by Harry Butzlaff, the Section's Education Committee Chairman.



Top—Officers of Rocky Mountain Section and Council seated left to right: Rocky Mountain Section President, Raymond I. Millard; National President, Frederick C. Sutro, Jr.; National Councilman, Rocky Mountain Section, Col. Oscar B. Yorker; Executive Secretary, Thomas A. Bissell. Standing, left to right: 1958 Past National President, R. Kenneth Gossett; National Treasurer, Haiman S. Nathan; Chairman, Publications Committee, Eugene C. Quear; Rocky Mountain Section Vice President, Richard Crawford; Administrator, Meetings, John Delmonte; Rocky Mountain Section Secretary, Neal C. Yorker; Rocky Mountain Section Treasurer, Burt Butcher; National First Vice President, George W. Martin; National Secretary, Frank W. Reynolds.

Left—Rocky Mountain Section makes full Westerner out of President Sutro. Left to right: Rocky Mountain Section President, Raymond I. Millard; National President Frederick C. Sutro, Jr.; National Councilman, Rocky Mountain Section, Col. Oscar B. Yorker.

Upper Midwest

Plant Tour and Picnic

Charles M. Smith

A tour of the Great Northern Oil Refinery at Pine Bend, Minn., took place on May 18th. The Pine Bend Refinery, largest and newest in the state of Minnesota, occupies nearly 1,000 acres on the south bank of the Mississippi River and adjacent to a main line of the Chicago Great Western Railway.

After the tour, a picnic was held on the Julian Baird estate on Sunfish Lake.

Quebec

Program Committee Sets Aims

Lloyd A. Meredith

During the May meeting the aims and difficulties of the Program Committee were discussed with the following being the main points made: the Section's biggest problem at present is to get members out to meetings and the program must be the drawing card. In order to appeal to the greatest number of members, speakers' topics should be as broad as possible and more forums or panels were suggested. Subjects not closely related to plastics should be avoided. It was the predominant feeling that our meeting day should be changed from Wednesday possibly to Tuesday or Thursday. Further discussion of this point was postponed for a subsequent Council meeting. Enough suggestions to cover programs for the next six meetings were received.

Speakers and Committees of Extrusion Workshop are pictured at Newark College of Engineering, Newark, N.J. during June 16-17 meeting, sponsored jointly by SPE Extrusion PAG and the SPE Newark Section. Left to right bottom row: Committee Members Newark Section, J. Schaul, Alpha Plastics; L. Ryder, Celanese; B. Zurkoff, Chairman, Union Carbide Plastics Co.; P. Monti, Celanese; A. Serle, President Newark Section SPE. Missing is R. Bostwick, Union Carbide Plastics Co. From left to right, speakers E. Veazey, Dow Chemical; B. H. Maddock, Union Carbide Plastics Co.; Dr. E. Bernhardt, DuPont; R. Sackett, Hartig Extruders; and moderator, M. Underwood, Monsanto Chemical Co.; Dr. Heinrich Kessler, DuPont. Missing is F. Nissel, Prodex.

Golden Gate

New Developments in Glass Fibers

Theo. V. Malianni

No business meeting was held when 65 members and guests met at the Paris Louvre restaurant, since President James Turner was unable to attend. Program Chairman William Richardson was appointed to act as general chairman. After dinner, he introduced Robert Mallory who in turn introduced the two speakers for the evening.

John Sabo, Owens-Corning Fiberglass, was suddenly called out of town so his prepared talk on "Roving and Mat" was read by Robert Elliott of the same company. Mr. Sabo's paper pointed out that today we have a greater variety of specific types of reinforcing materials for the plastic industry than either steel or aluminum manufacturers. We have rovings compatible with all basic laminating resins; a number of end variations, hardness and fuzz factors; wettability rates and various degrees of cuttability. Newer products include R-600 roving that disperses better but without fuzz, wets out faster and imparts a finer texture. M-506 mat is a new reinforcing mat in which R-600 is used. Spun roving which is used for preform and also in conjunction with standard roving in Marine type woven roving material; and Flakglas premix which is sprayed on a surface as a protective coating.

Looking into the future, Mr. Sabo predicted that we can expect several new developments such as fiber length control in a reinforcing mat pack, improvement of basic glass properties which will enable us to produce high modulus and higher temperature glasses, and an acrylic binder system on reinforcing mat.

In conclusion, he gave a brief resume of how Owens-Corning is continuing to improve their facilities in hopes of advancing the technology of the production and utilization of fibrous glass as a basic raw material. Special programs in their laboratory today include studies of reinforcement in various resin systems; new plastic sizes for glass strands which include solvent binder systems; and combination mat reinforcements and special strand packaging.

The second talk was by Henry M. Toellner of the fabrics division of Coast Mfg. & Supply Co., who gave a comprehensive analysis of "Preimpregnated Materials as a Raw Material for Reinforced Plastics."

Mr. Toellner compared the advantages and disadvantages of wet lay-up versus preimpregnation. While wet lay-up embraces low tooling and requires less skill by personnel, it is messy and offers poor control of resin content. Long run items of course, are costly. Preimpregnation on the other hand is costly for short run items but gives higher strength due to resin content control and use of high temperature and high pressure cures.

At present, there are four available preimpregnated systems which of course will be expanded. First, the phenolics which give good strength at all temperatures up to 600°F and are easily tailored to fabricators' needs. Second, the epoxies which have high moderate temperature strength, good electrical properties and good dimensional stability. Third, the polyesters which also have good electrical properties and make low temperatures and short cures possible. Fourth, the silicones which give low strength but are noted for strength retention at elevated temperatures. In closing, Mr. Toellner outlined the aims of his company regarding new developments in resins and reinforcements. In resins, they are working on flame-resistant epoxies and polyesters, and phenyl silanes. On reinforcements, developments include quartz fabric and paper; potassium titanate, polyethylene and polypropylene fabric and acrylic fabric.

St. Louis

Architectural Uses of Plastics

Lyle R. Dean

Speaker at the May 18th meeting, was Col. Herbert R. Tumin, U.S.A., Retired. Forty members and guests were present.

Col. Tumin has been with Monsanto Chemical Co., in the Research and Engineering Group for over four years. He was in charge of choosing all of the plastic materials used in the construction of the new Monsanto offices and laboratory on Olive Street Road in St. Louis, Mo. This building is one of the leading examples of the latest applications of plastics in construction. Col. Tumin showed a movie "Architectural Uses of Plastics" which describes some of these plastic applications and some of the fabricating techniques. He explained that there were over 80 different plastics applications in this building, including exterior wall panels, lighting louvers, instrument tubing, pipe for water, exhaust ducts and hoods, decorative paneling, floor coverings and many other applications. Col. Tumin stated that they had had only minor difficulties with some eight of these applications and most of these were due to climatic conditions during installation.

Toledo

Epoxy Resins

R. E. Dunham

At the May 20th meeting, three students interested in plastics were entertained. Six Toledo high schools and the University of Toledo were represented from this group who heard Dr. Harold Golden, Resin-Chem Corp. and Howard Henderson, Ren Plastics, Inc., speak on "Epoxy Resins and Their Use."

Dr. Golden outlined the resin and chemical part of the program while Mr. Henderson described the use of epoxy resins, particularly in tooling. High strength, chemical resistance, low shrinkage, high temperature resistance and adhesion to many surfaces determine the field in which epoxies can be utilized. Commercial applications exist in finishes, adhesives, cold solder, potting and encapsulating and laminating to bring about 40-million pound usage now and a predicted 75-million pound usage in 1960.

Today there are many types of epoxy resins and combinations with curing agents to bring about hundreds of basic resins with heat resistance varying from 100°C to 33°C. Prices are high but excellent properties of the materials still make them very desirable.

Mechanical, thermal, chemical and electrical properties along with dimensional stability make epoxy resin combinations superior to metal for many applications. This is particularly true when savings are secured due to the casting of plastic tools rather than forming the tools from metal. Limitations due to the geometry of a part, heat requirements or needed abrasion resistance should be recognized in planning the use of epoxies.

The annual outing will be a Reef Fishing Trip on Saturday, August 1, 1959.

Central Ohio

Polypropylene and Its Uses

Gary C. Fulmer

In the absence of President Bob Zimmerman and Vice President William D. Rackett, Secretary Gary Fulmer opened the May meeting with the Secretary's report.

Minutes of the April meeting were read and approved.

Preceding dinner, a very brief business meeting was held. There was no old business, and new business consisted of reminding the members of the June 23rd Golf Outing at the Pickaway Country Club. Members were asked to try to obtain door prizes from their companies.

At the conclusion of the business meeting and dinner, Mr. Kuhlmann introduced our speaker for the evening, Dr. W. Paul Acton, Hercules Powder Co. Dr. Acton spoke on Pro-Fax polypropylene, demonstrating with slides.

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ABOUT MEMBERS

Gerry P. Mack, formerly product manager for stabilizers, has been appointed product manager for the entire line of organic chemicals manufactured by Metal & Thermit Corp., N. Y. Mr. Mack joined Metal & Thermit in 1955 as director of M&T Laboratories Inc., and in 1957 he was appointed product manager of Thermolite heat and light stabilizers for vinyl plastics. He attended the University of Chicago and Brooklyn Polytechnic Institute. He is an active member of the American Chemical Society, American Society for Testing Materials, the New York Section of SPE, and SPI.

Gerry P. Mack

Millard Demarest

Millard Demarest, Newark Section of SPE, was named sales manager of Auto-Vac Co., a division of National Tool Co. Previously associated with the Plastics Div., of Celanese Corporation, Extrusions, Inc. and Welding Engineers, Inc., Mr. Demarest has been active in the plastic industry for several years.

Richard K. Senn, member of the Akron Section of SPE. was appointed manager of extruder sales for National Rubber Machinery Co. Prior to joining this company, Mr. Senn was a project engineer at Hale & Kulgren, Inc., and earlier was employed by Goodyear Tire & Rubber Co. He attended Ohio State University, and Ohio University.

Wayne Hays has joined The Kendall Co., Kendall Mills Div. Mr. Hays, a chemical engineer, will work exclusively on the development of non-woven fabrics and related processes in the Walpole plant. He is a member of the American Association of Textile Chemists & Colorists, Southern Section of SPE, and the ASTM. Mr. Hays was formerly associated with Calloway Mills and Sinclair Oil & Gas Co.

Alfred Coz announces the formation of a new organization, Coz Chemical Corp. The plant and laboratory, located in Northbridge, Mass. will be in full operation by May 15th, producing thermoplastic materials. The new plant, fully automated, will occupy an area of over 31,000 sq. feet on one floor. Both Mr. Coz and his brother Henry have been associated with the plastics industry for over fourteen years. **Henry Coz** has been appointed sales manager for the New England area, a territory that he has covered in the past while servicing users of thermoplastic materials. Both men are affiliated with the Pioneer Valley Section of SPE.

Alfred Coz

Henry Coz

Francis L. Terhune has been appointed assistant development manager at the Borden Chemical Company's Resinite Dept. plant in North Andover, Mass., it was announced by James A. Wold, general manager of Borden's Resinite operations. Mr. Turhune, who joined Borden's as a chemist when the company acquired Resin Industries of Santa Barbara, Calif., in 1956, was transferred to North Andover last November. He attended Western Illinois State University, where he majored in chemistry, and was graduated with a BS degree in 1950. Mr. Turhune is an affiliate of the Southern California Section of SPE.

Warren Peterson, a member of the Newark Section of SPE, was named manager of the Middle Atlantic and Southern sales district of the W. R. Grace & Co., Polymer Chemicals Division. His home office will be in Clifton, N. J., and the district will include the area south of New England to Florida and to the west as far as Mississippi, Tennessee, Kentucky, and Ohio.

C. J. Bridgen, a member of the SPE Chicago Section, has been appointed district sales manager in Chicago for the Spencer Chemical Co.

Ralph Biondi has been named manager, Northeastern sales district of W. R. Grace & Co., Polymer Chemicals Div. Mr. Biondi will be based in Clifton, N. J. His territory will comprise N. Y. and all of New England. He is a member of the N. Y. Section of SPE.

Herbert R. Erickson, development manager of the Borden Chemical Company's Resinite Dept., plant in North Andover, Mass., has assumed the additional responsibilities of operations manager. In his new position, Mr. Erickson will be responsible for the development, production, and engineering departments of the North Andover operation. He is a member of the SPE.

DeWitt Cheney was appointed manager, Western sales district of W. R. Grace & Co. This district is from the Eastern Colorado border to California, including the Pacific Northwest. Mr. Cheney is affiliated with the Southern California Section of SPE.

Three SPE National Officers participated in the session devoted to plastics and elastomers of the SAE summer meeting held in Atlantic City on June 19. **President Frederick C. Sutro, Jr.**, spoke on cooperation between SAE and SPE; **Past President J. Harry Du Bois** presented a paper on "The Expanding Polymer Horizon," and **Past President William O. Bracken** delivered a prepared discussion of Mr. Du Bois' paper.

Howard F. Modjeski, Chicago SPE affiliate, has joined the engineering staff of Midwest Technical Service, Downers Grove, Illinois. The company serves as engineers and consultants to the plastics industry.

Samuel G. Salzinger, member of the Golden Gate Section has resigned his position in the Research & Development of Coast Manufacturing & Supply Co., to join with Reinhold Engineering & Plastics Co. as technical representative for Northern California and the Pacific Northwest. He will also head a new firm called Caryle Chemical Corp. to manufacture and market a new charcoal briquet for barbecue and other such uses. These briquets will be plastic coated.

Raymond B. Seymour, General Co-Chairman of the First NATEC, has been made President of the Southern California Chapter of SPI. Mr. Seymour is with Loven Chemical of California. He is affiliated with the Southern California Section of SPE.

John Delmonte, SPE National Councilman representing the Southern Section, has been named Chairman of the West Coast Section of SPI. Mr. Delmonte also is Administrator, SPE National Meetings Committee, Member of National Executive Committee, and President, Furane Plastics, Inc.

Dr. Elmer Warnken president of C.T.L. Inc., was awarded the annual Space Industries Small Business Award. Dr. Warnken, a prominent scientist and member of the Miami Valley Section of SPE, was on a business mission in the Caribbean area during the time of presentation. This award was accepted by Melvin N. Korelitz, C.T.L. vice president. It was made at the Missile Industry Luncheon of the 1959 National Missile Industry Conference. C.T.L. was given the coveted small business award for its contribution to the successful solution of Jupiter IRBM reentry problems. Jupiter is a 1650-mile, nuclear warhead ballistic missile developed by the Army and scheduled for deployment in Europe by the Air Force Strategic Air Command. C.T.L. developed both the materials and the methods for perfecting the ablation approach to reentry.

Robert L. Davidson, an affiliate of the Miami Valley Section of SPE, was elected vice president and director of SPE. He is vice president of Kurz-Kasch, Inc., Dayton, Ohio. Mr. Davidson was elected for a two year term commencing June 1st.

F. D. Oberkircher, Jr., a member of the Northwest Pa., Section of SPE, has been promoted from sales engineer to sales supervisor, Nosco Plastics, in charge of the home office, upper N. Y. state, and Midwest territories. He has been with Nosco ten years.

PRODUCT-DESIGN BRIEFS FROM DUREZ

Phenolic adds efficiency to blower wheel

DENSO ENGINEERING & SALES CO., INC.

Molded of a Durez general-purpose phenolic, this blower wheel has extra-large blade area. No end ring is needed to keep the blades from bending. Concentricity is molded in; wobble is less than with comparably priced metal wheels. *For ideas on how and where to apply Durez phenolics in your products, write for Bulletin D400.*

Vandals can't slash these bus seats

AMERICAN SEATING COMPANY

Bus seats made with tough, fire-retardant Hetron® polyester, foil vandals who used to slash upholstered seats, causing damages of $100,000 a year. The new seats cost less, wear longer than upholstered seats. And passengers like them better. *Want to know more about this strong structural plastic that retards fire? Ask for the complete data file on Hetron resins.*

Resin locks cork granules in firm grip

KENTILE, INC.

Not even boiling water can weaken this cork floor tile bonded with Durez phenolic resin. Many manufacturers are improving products with heat-setting resins from Durez that add hardness, heat and moisture resistance, abrasion resistance, other properties. *A 12-page bulletin describes and illustrates how it's done. Send for it.*

DUREZ PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION

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HOOKER CHEMICALS PLASTICS

NOW...a new dimension BAKELITE Polyethylene

BRAND

Here's the first of a new series of polyethylenes for molding. It gives you far better properties than any other general purpose polyethylene. Remember the name . . . BAKELITE Brand Polyethylene Copolymer!

Look at these advantages . . . unmatched by any other polyethylene:

Low Temperature Toughness. After four hours at 40 degrees below freezing, garbage cans showed no cracks when dropped 6 feet onto a concrete floor.

Stress Cracking Resistance. BAKELITE Polyethylene Copolymer averages six times better than conventional polyethylene.

Flex Life. Conventional polyethylenes failed at 30 thousand flexing cycles. No damage to BAKELITE Polyethylene Copolymer after 200 thousand cycles.

Rigidity. BAKELITE Polyethylene Copolymer is one-third more rigid than general purpose polyethylenes of similar flow.

Gloss and Moldability. Compares with or surpasses the better general purpose polyethylenes currently available.

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TYPICAL PROPERTIES OF DPD-7365

Property	Value
Melt Index, g/10 min.	8
Density, g/cc at 23°C	0.935
Secant Modulus, psi	40,000
Tensile Strength, psi	1600
Elongation, %	210
Yield Strength, psi	1500
Brittle Temperature, °C	
50% OK	−70
80% OK	−60
Stress Cracking Resistance	
50% Failures, hours	>336
Mechanical Flex Life, No. of Flexes	200,000

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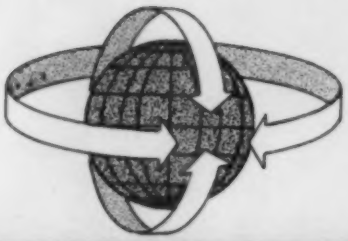

PLASTICS AROUND THE WORLD

★

GREAT BRITAIN

RUBBER AND PLASTICS AGE

June, 1958

Abstracter: Walter A. Gammel, Sr.

Plastics in New Buildings—

The author reviews American progress in the use of plastics in new building. Reference is made to the "House of the Future," the contributions of M.I.T., Monsanto Chemical, and Penn State. He regrets that the British do not have a Plastics Study Group as has the U.S.A. in the Building Research Institute.

PLASTICS

December 1958

Abstracter: Alfred Rexer

Laminates of PVC to Steel and Hardboard— W. E. Martin

A four page article describes the laminating of PVC to dissimilar materials. The principles involved and the difficulties which have been experienced in developing the laminating process are discussed.

Long-Term Behavior of Drinking Water Pipe From Ziegler—Polyethylene—Dr. Ing K. Richard, Dipl. Ing. E. Gaube and Ing. G. Diedrich

A three-page article, well illustrated with charts, gives plastics research on long-term tests extending over many years, prediction of the life time of plastic tubes, and specification of the maximum safety stresses in order to calculate the required thickness of water tubes.

Polyurethane Synthetic Rubber—Anon.

A two-page article describing the history, chemistry, properties and applications of the moldable grades of polyurethanes.

Cellulose Propionate—Part II—D. A. Jones

A three-page article describes the uses and applications of cellulose propionate. General properties and several application case histories are given.

Serigraphic Printing on Plastics—E. Mertes

A manufacturer of serigraphic printing equipment discusses the problems and advantages of this type of package decorating. He also describes and illustrates the machines produced by his own organization for special shapes, sizes and materials.

INDUSTRIE DES PLASTIQUES MODERNES

September—October 1958

Abstracter: Hans Mayer

Plastics at the Brussels Fair—George Fabre

A full description of plastic materials used as building or display parts as well as a description of plastics as exhibited and demonstrated by exhibitors is given.

The Use of "Ribsan" Film in Agriculture—J. Soyeur

This report deals with extended tests, made over a period of time in different parts of France and abroad regarding the practical results achieved in substituting this material for glass in hot beds, greenhouses and as protective covering.

Induction Heating in Plastic Curing—P. Drapier

The nature of induction heating and its application in the manufacture of resins, in extrusion, in molding as applied in or outside of the mold are described.

November 1958

A New Market For Polyethylene Pipe: Underwater Crossing—Anon.

A technique for the improvement of underwater crossings of water bodies with cables and other electrical conductors by means of polyethylene pipes is described.

Terphane, A Plastic Film With Various Applications—Anon.

Terphane is a polyester film, highly transparent and of excellent physical properties. These and the various applications tried as well as recommended are enumerated.

December 1958

Molecular Sieve With Chemical Reagents—Anon.

The composition of thermosetting materials is frequently influenced by the fact that the catalyst cannot shorten the shelf life of the material to the extent of making the handling of the finished composition impossible. This is particularly the case when a peroxide base catalyst is being used. Resin and catalyst have to be stored separately and combined as closely to the time of use as possible.

A method of overcoming this difficulty is described. Some minerals of the Zeolite type are highly absorbent by nature. If the moisture stored by these minerals is driven off, a large number of small, channel-like openings appear and are ready to absorb and attach to the mineral other liquids like benzon-peroxide in lieu of the original water content. The catalytic charge cannot be driven off unless heat is applied. It therefore becomes possible to store the catalyst in this form together with the resin. When the resin is put to use, no action will be triggered by the catalyst until the heat has reached the point of releasing it from its mineral storage.

★

ITALY

MATERIE PLASTICHE
October, 1958

Abstracter: Alfred L. Alk

The Principal World Markets of Plastics in 1957—G. Moretti

A compilation and discussion of statistics on the plastics industry of the United Kingdom, France, USA, Japan, West Germany and Italy.

Polyvinyl Butyral and Its Use in Laminated Glass Structures—A. Camerini and L. Lucchetti

After presenting various types of transparent safety glazing, glass laminates in general are discussed and the advantages of using polyvinyl butyral are demonstrated. Preparation of the compound, additives used and processing characteristics are then presented with graphs and tables illustrating physical and chemical properties. Finally the methods of preparation of plastic sheets are described and the processes for laminating to make safety glass.

Forcing Asparagus Under Polyethylene Film—L. Girolami

A four-year-old planting was selected. One of eleven beds was covered with polyethylene following the normal spring fertilizing and mulching and immediately after an ample rain. The spring was cold and wet. After 17 days the first sprouts came up under the cover, and on the 20th, the first tips were gathered. First tips from the uncovered beds were not gathered until 17 days later. The covered plot produced more than the uncovered during the season. When the beds began producing equally each day, the films were removed. It was determinated that (*a*) covering the beds gave a crop 17 days sooner (*b*) the early crop received up to five times the price of the later crop (*c*) net gain was about 50% higher per acre (*d*) and costs could be lowered in future by utilizing experience gained the first year.

Using Polyethylene for Waterproofing a Tunnel—E. Chiostri

Concrete tunnels at Montecatini Spa were difficult to waterproof because of the presence in the soil of mineral springs. To make the tunnel completely impervious, the reinforced concrete side walls were covered with a 4-mil film after the removal of the forms and the space left in the trench was filled with damp clay. The film was folded over the top and another sheet, which covered the roof, was heat sealed to each side using hot gas welding. The top of the structure was covered with 4 inches of concrete to protect the film and garden soil was replaced about it.

Properties of Moplen Pipe—F. Ranalli

The working properties of Moplen polypropylene pipe are here determined and compared to well known pipe resins like polyethylene and PVC. The circumferential breaking strength was chosen as the principal parameter for evaluating performance.

As secondary parameter the resistance to pressure was chosen, as, especially in the case of higher molecular weight Moplen, it can be a limiting factor in the use of the resin. Test methods and results are supplied in detail.

Degradation by Heat and Oxygen of Olefinic and Diolefinic Polymers—P. Maltese

Natural and synthetic polymers containing only carbon and hydrogen are subject to degradation, 1) during fabrication by: heat, shear, etc, and 2) during the subsequent life of the material, caused essentially by heat, light and oxygen. The effects of each cannot be completely isolated; each common production method provides its own combination of them. Auto-oxidation is treated in a general way in the article with the means of combatting it in polymers; in a similar manner, the methods of studying autoxidation are investigated and the most important aspects are enumerated: kinetics, calculation of the energy of activation, variation of mechanical properties of polymers subjected to oxidation, followed by a brief review of the reaction of several polymers to oxidation and, finally, the general principles of action by anti-oxidants.

Plastics in the Field of Surgery—M. Bornengo

Plastics have long been used as surgical accessories such as gloves, catherters, otoscopes. Now plastics are being used to replace parts of the body. The body has high tolerance for many plastics; for example polyvinypyrrolidone, which is 3.5% solution modified with sodium chloride is used as a blood extender. In general polyethylene, polyacrylates and nylon satisfy the requirements of body tissue against irritants allergens, and so on and are also dimensionally stable enough for internal use.

Polyethylene, as tubing and sheeting, is frequently used. It has recently been substituted for the dura mater which protects brain tissue. In this application it was sutured to nearby membranes. Polyethylene sponge and a polyethylene sac filled with glass fibers have been successfuly installed in pneumothorax to keep the lung collapsed. Polyethlene cups have been inserted between head of femur and socket for osteoarthritis. Nets woven of polyethylene fiber have been used in treating hernia and the solid plastic has been used to replace nasal cartilage.

Nylon has had its greatest use in woven and monofilament sutures, because it is strong, nonabsorbable and nonirritating, and does not allow passage of body fluids

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between its fibers. Nylon fabrics are used to strengthen as in hernia, and in heavier gauge to repair the cranium.

Polyacrylates greatest use is in dental replacements where they have replaced a considerable amount of porcelain. They have been successfuly used in maxillofacial surgery, in the reconstruction of frontal sinuses and nasal structures. The resins do not adhere naturally to the tissues and must be immobilized against bone or sewed onto neighboring tissues. They are particularly adapted for use as blood vessels because of not affecting the coagulation of the blood and they resist the blood pressure. Acrylic tubes have been used to replace part of the aorta and to replace a defective aortic valve. Acrylic cranial plates held in place with stainless steel wires have proven successful.

★

GERMANY

KUNSTSTOFFE
July, 1958

Abstracter: Charles S. Imig

Polypropylene—Dr. Gerhard Bier

Reaction mechanisms for the polymerization of propylene using stereo-specific catalysts, differing from the Natta catalysts, are presented along with the effect of reaction conditions on polymerization rate and molecular weight. Properties of the polymers of propylene are compared with polyethylenes, styrene, vinyl, acrylic and nylon.

Properties of Foamed Cold Setting Urea-Formaldehyde Resins—H. Baumann

A number of useful tests developed by the author are described for testing foamed cold setting urea-formaldehyde resins. These tests include: shrinkage, low temperature properties, resistance to heat, aging resistance, chemical resistance, effect of vibration, effect of fungal growth, effect of other materials, formation of condensed water, thermal conductivity and water absorption.

High Polymer Materials—Part 3—Dr. Ottmar Leuchs

Relationship between the softening of high polymers at elevated temperatures and the two molecular properties of "molecular structure" and "inter-molecular forces," are described in this paper. The first, molecular structure, explains melt elasticity, plasticity in thermoplastics, absence of low viscosity as well as the extent of this viscosity, and partial crystallinity. The second, inter-molecular forces, explains low temperature rigidity, wide freezing range, and the existence of the crystalline range insofar as allowed by the molecular structure.

September-October 1958

Thermoforming of Polyethylene—Dr. H. Peukert

Elastic recovery of thermoformed polyethylene sheeting was studied and revealed that optimum thermoforming temperatures were between 100°-105°C (212°-221°F).

Tannin-Formaldehyde Adhesives—Dr.-Ing. D. Narayanamurti and N. R. Das

Tannin-formaldehyde wood adhesives may be prepared from tannin extracted from the bark of tropical trees. The composition, properties and methods of application are discussed. Promising uses are discussed as well as showing that it is compatible with phenol-formaldehyde adhesives.

Plastics in Packaging. Investigations into the Use of Plastics Sheeting for Foodstuffs Packaging—Dr. L. Robinson-Görnhardt

Of importance in the use of plastics in the packaging of foodstuffs is the need to determine if there is any danger in migration of harmful substances from the plastic to the food. Methods of test are described which would prove useful. These would include weight loss tests, solubilities, high temperature tests and actual end use tests on the food to be packaged.

Removal of Flash From Mass Produced Moldings—Han Derigs

Comparison is made between several methods of drum tumbling with manual deflashing of parts. Results of practical experience in utilizing these methods are reported. Drums best suited for complicated parts are discussed as well as limitations imposed by type and form of filler and the thickness of the flash. Economics of the different methods are reviewed.

Type of Electrodes Used for H. F. Welding PVC Sheeting. The Guillotine Edge—Kurt Bradenburger

The final appearance of an H.F. welded seam in PVC sheeting is governed by the nature of the lower edge of the electrode. Various types of electrodes are described and the arrangement of the guillotine edge is discussed. Among other factors discussed are welding pressure and support used during welding.

November 1958

Cleaning of Spinnerets by the Kolene Process—Dr. Rudolf Kuhn

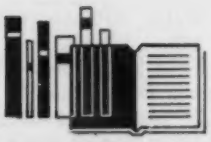
Dipping the spinnerets in Kolene-15 at 400-500°C destroys all organic material and absorbs all non-metallic pigments like TiO_2. After treatment, hot water, cold water, dilute acetic acid and distilled water washes are employed. Comparative results are shown.

Perfection of High Polymer Materials and Techniques—Dr.-Ing. Karl Mienes

Recent examples of attempts by the plastics industry to adjust the properties of high polymers to suit the need of processors and ultimate consumers are given. Adjustment of melt index and density of polyethylenes are discussed as are new techniques for manufacturing thin walled high density polyethylene parts. New molding techniques developed by Foster Grant and Paul Troester, independently, capable of faster cycles are mentioned. Blow molding of high-impact styrene and nylons are discussed critically. Also, polystyrene and polyurethane.

The Manufacture of Transparent Cartons—Kurt Brandenburger

Semi-rigid transparent containers are discussed. Cellulose acetate sheeting between 0.0006 and 0.008 inches thick is considered most suitable. Machinery to cut, fold and weld the cartons is described as is the manufacture of circular containers. Use of thinner sheet, savings in equipment cost, high output and low initial outlay are claimed as advantages of the described methods.



BOOK REVIEWS

SILICONES

R. N. Meals and F. M. Lewis, Reinhold Publishing Corp., N. Y., 1959.

This work covers the technology and applications of silicones in a concise, readily assimilable form. Contrary to many treatments intended for industrial engineers and designers, this one is never condescending.

The presentation is well done; data are given in useful engineering units, tables and figures are constructed for easy access to the data, and generalizations are suitably qualified and limited. The synthetic routes to the various silicones are well described in the chapter on Basic Chemistry.

This book can be recommended to the plastics engineer requiring a well-organized introduction to the properties and uses of silicones.

E. H. Merz
Monsanto Chemical Company

EPOXY RESINS

Irving Skeist

"Epoxy Resins" by Mr. Skeist is a good, quick reference manual for experienced, as well as for novice users of epoxy resins.

The book can be divided into three sections; (1) the manufacture of epoxy resins; (2) the curing and modification of epoxy resins; and (3) the applications of epoxy resins.

The first section describes in layman's language the various properties of resins obtained from different starting materials. Information and data is given primarily on resins made from epichlorohydrin and bisphenol A.

The second section outlines the various curing mechanisms available with epoxy resins and discusses several curing agents and their properties. It also advises the user of epoxies about modifications obtainable by the use of fillers, diluents, and flexibilizers.

The third section deals with the applications of epoxies. A thorough description of epoxies in tooling, electrical, adhesive and casting applications is given, listing several formulations for numerous applications. Data is presented showing the effect on tool life, bond strength, dielectric contrast, chemical resistance, etc. when various curing agents and fillers are used.

Tool engineers, plastic engineers, chemists, purchasing agents, and laymen will find this book easy to read.

Richard T. O'Connor
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Encapsulation, Printed Circuits, and Fluidized Bed Processes—Northern Indiana Section, 15 of 23 papers presented. $3.00 members; $4.50 non-members. (See program SPE Journal, April, 1959, p. 319).

Plastics in the Automotive Industry—Detroit Section, 4 papers, $2.00 members; $3.00 non-members. (See program SPE Journal, May, 1959, p. 443).

Other 1959 RETEC Preprint Books

BOATS, AIRCRAFT & MISSILES

★ **A Designer's Look at Reinforced Plastics from the Pleasure Boat, Aircraft and Missile Industries Viewpoint**—North Texas Section, 6 papers. $2.00 members; $3.00 non-members. (See program SPE Journal, April, 1959, p. 324).

METALS INDUSTRIES

★ **Plastics in the Metals Industries**—Pittsburgh Section, 10 papers. $3.00 members; $4.50 non-members. (See program SPE Journal, April, 1959, p. 324).

SPE PLASTICS ENGINEERING SERIES

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Vol. IV, 1958, Detroit, 94 papers. $5.00, members; $7.50, non-members.

Vol. III, 1957, St. Louis, 60 papers. $5.00, members; $7.50, non-members.

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(Continued from page 563)

"Progress in Extrusion", E. C. Bernhardt, *Plastics Engineering*, December 1958.

"The Plastics Extruder and the Packaging Industry", Albert A. Kaufman, *SPE Journal*, January 1959.

"Continuous Extrusion and Thermal Curing of Insulation", Philip H. Rhodes and H. C. Black, *SPE Journal*, January 1959.

"Sheet Extrusion Problems and Solutions", A. L. Griff, *SPE Journal*, January 1959.

"Application of Extruder Pressure Measurement Equipment", G. A. Pettit, *SPE Journal*, January 1959.

"Extrusion Variables Affecting High Impact Styrene Sheet Manufacture", W. A. Kelly and W. E. Welch, *SPE Journal*, January 1959.

"Nylon Film Properties", Robert L. Hughes and Dannon G. Simpson, *SPE Journal*, January 1959.

"Section Extrusion of Rigid PVC", G. H. Burke and A. E. Parker, *British Plastics*, March 1959.

"Extrusion of Polyethylene Film With Controlled Properties", W. A. Haine and H. B. Robinson, *SPE Journal*, March 1959.

Ω

List Approved American Plastics Standards

Fifteen plastics standards published by the American Society for Testing Materials have been approved as American Standards by the American Standards Association. Included are four standard specifications, 10 standard methods test, and one standard method of measuring.

These standards were formulated by ASTM Technical Committee D-20 on Plastics which now numbers over 400 members. The standards were developed during the early and middle 1940's (most with subsequent revisions in the 50's) and have achieved national recognition and broad general acceptance as the standards for this industry. The ASTM recommendation on their approval as American Standards was endorsed by the Society of the Plastics Engineers.

The ASTM standards approved as American Standards, their ASTM designations and their ASA numbers are as follows:

Standard Specifications for Ethyl Cellulose Molding Compounds, ASTM D 787-55, ASA K64.1-1959.

Standard Specifications for Cellulose Acetate Plastic Sheets, ASTM D 786-49, ASA K64.2-1959.

Standard Specifications for Cellulose Nitrate (Pyroxylin) Plastic Sheets, ASTM D 701-49, ASA K64.3-1959.

Standard Method of Test for Stiffness Properties of Nonrigid Plastics as a Function of Temperature by Means of a Torsional Test, ASTM D 1043-51, ASA K65.2-1959.

Standard Method of Test for Rockwell Hardness of Plastics and Electrical Insulating Materials, ASTM D 785-51, ASA K65.3-1959.

Standard Methods of Test for Deformation of Plastics Under Load, ASTM D 621-51, ASA K65.4-1959.

Standard Method of Test for Haze and Luminous Transmittance of Transparent Plastics, ASTM D 1003-52, ASA K65.5-1959.

Standard Method of Test for Luminous Reflectance, Transmittance, and Color of Materials, ASTM D 791-54, ASA K65.6-1959.

Standard Methods of Test for Specific Gravity of Plastics, ASTM D 792-50, ASA K65.8-1959.

Standard Method of Test for Total Chlorine in Vinyl Chloride Polymers and Copolymers, ASTM D 1303-55, ASA K65.9-1959.

Standard Method of Test for Ammonia in Phenol-Formaldehyde Molded Materials, ASTM D 834-57, ASA K65.11-1959

Standard Method of Test for Acetone Extraction of Phenolic Molded or Laminated Products, ASTM D 494-46, ASA K65.12-1959.

Standard Specifications for Molds for Test Specimens of Plastic Molding Materials, ASTM D 647-57, ASA K66.1-1959.

Standard Method of Test for Apparent Density and Bulk Factor of Granular Thermoplastic Molding Powder, ASTM D 1182-54, ASA K66.2-1959.

Standard Method of Measuring Shrinkage from Mold Dimensions of Molded Plastics, ASTM D 955-51, ASA K66.3-1959.

Also approved as American Standard is ASTM D 1243-58T, Tentative Method of Test for Dilute Solution Viscosity of Vinyl Chloride Polymers. The ASA number is K65.10-1959.

Copies of the newly approved American Standards are available at 30 cents each from the American Standards Association, 70 East 45th Street, Dept. PR 73, New York 17, N.Y.

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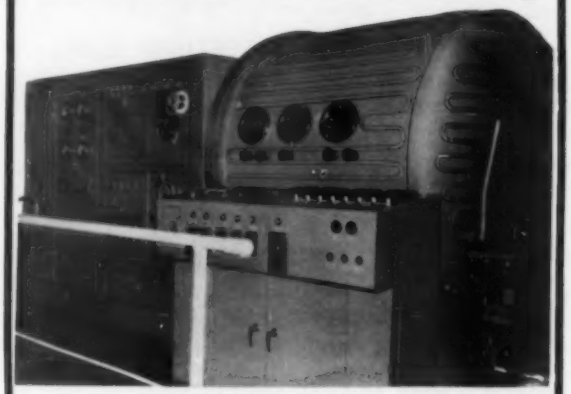

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(Continued from page 591)

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Report on Eighth International Meeting of ISO Technical Committee on Plastics Available Free to SPE Members

An annual report of ISO/TC-61 Committee on Plastics for 1958, is being offered free of charge to all interested SPE members. Larger quantities can be obtained for a small nominal charge. SPE is pleased to extend this service in order that members may receive a comprehensive report of this important meeting held in Washington, D. C. November 3-8, 1958.

This 68-page document contains information on all activities and events which took place during the meeting, as well as details on international plastics developments and progress in the establishment of plastics standards.

It carries the minutes of the eight ISO/TC-61 Working Groups and the first draft on five ISO Recommendations.

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Changing the resin?

Changing the product?...

NO PROBLEM

with HARTIG equipment

Hartig 3½" Extruder
L/D Ratio, 21:1
Effective Screw Length: 73½"
Nominal Capacity: 200-250 lbs./hr.
Barrel Heat: 13 bands, 2500 W ea.
Control Zones: barrel 3, die 1
Temperature Controls: 4 (proportioning)
Thrust Bearing Capacity: 221,900 lbs.
Floor Dimensions: 111" x 70" (belt drive)
Weight (approx.): 5000 lbs.
Motor Drive (belt): 25-40 hp.

Each Hartig extruder has been designed to do a specific job – at maximum efficiency. It has also been designed so that a new job setup can be handled at equal efficiency with only minor modifications.

Motor, drive, base, barrel and controls need not be changed. Screws suitable for processing the various new materials are readily interchangeable. Quick opening clamp type head, a Hartig first, makes die change fast and easy.

When you buy a Hartig extruder, you can be sure of the highest production rate for each job—for years to come. Let us show you the facts and figures.

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